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REGRESSION SIMULATION OF TURBINE ENGINE PERFORMANCE - ACCURACY IMPROVEMENT (TASK IV)

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Pratt & Whitney Aircraft Group
Government Products Division
West Palm Beach, Florida 33402

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Air Force Systems Command
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The Regression Simulation of Turbine Engine Performance (RSTEP) Task IV program was an analytical study to identify and evaluate approaches to improve the accuracy of regression surfaces for use in TEVCS/ARES procedures. The Central Composite Design (CCD) data selection pattern was studied and found to be a flexible, accurate, and economical alternative to the orthogonal Latin Square design selector. The impact of the number of independent variables and the number of data points was systematically investigated. Two methodologies which provided significant improvement in the accuracy of the regression surfaces were also identified.

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FOREWORD

This final report was prepared in accordance with Contract F33615-77-C-2109, Project 3066, Task II, Regression Simulation of Turbine Engine Performance, Task IV. The program was performed under the direction of Mr. J. R. Ruble, AFAPL/TBA of the Air Force Aero Propulsion Laboratory. It presents the work conducted by Pratt & Whitney Aircraft Group of United Technologies Corporation, P. O. Box 2691, West Palm Beach, Florida 33401, in accordance with Sequence No. 7 of Attachment 1 (DD Form 1423) of the contract. The work was performed under the direction of Mr. J. A. Sabatella, Jr. of Pratt & Whitney Aircraft Group during the period September 1977 through September 1978. This report was submitted in September 1978.

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LIST OF SYMBOLS AND ABBREVIATIONS

AES	=	Advanced Engine Simulation Study
AR	=	Wing Aspect Ratio
ARES	=	Airplane Responsive Engine Selection Study
A8	=	Airflow Schedule
BPR	=	Bypass Ratio
CET	=	Combustor Exit Temperature, °F
D	=	Engine Diameter at Customer Connect, ft
FPR	=	Fan Pressure Ratio
K	=	Constant
L	=	Engine Length, ft
N	=	Derivative Exponent, Transformation Methodology
OPR	=	Overall Pressure Ratio
PEE	=	Percentage Error of Estimate
RADIUS	=	Dash Radius, NM
R^2	=	Correlation Coefficient
SEE	=	Standard Error of Estimate
SWEEP	=	Wing Leading Edge Sweep Angle, Degrees
TEVCS	=	Turbine Engine Variable Cycle Selection Study
TOGW	=	Take-Off Gross Weight, lb
TR	=	Throttle Ratio
T/W	=	Thrust to Weight Ratio
W/S	=	Wing Loading, lb/ft^2
$\frac{W_{fuel}}{TOGW}$	=	Fuel Fraction
$\frac{W_{propulsion}}{TOGW}$	=	Propulsion Fraction
t/c	=	Thickness to Chord Ratio

SUMMARY

The TEVCS/ARES methodology was devised to assist in the selection and optimization of advanced weapon systems. This methodology was developed by McDonnell Aircraft Company and the Boeing Aerospace Company under contract to the USAF. The Regression Simulation of Turbine Engine Performance (RSTEP), Task IV program is an analytical study to identify and evaluate alternate approaches that may be used in TEVCS/ARES procedures to produce system regression surfaces that more accurately reflect the trends of the baseline aircraft design/mission analysis program. A second objective of RSTEP is to reduce the cost of data generation required by the TEVCS/ARES procedures.

The study was conducted by Pratt & Whitney Aircraft Group, GPD, with airframe/mission data provided by the Boeing Aerospace Company. This data was consistent with the data base generated during the ARES program, and consisted of mission related output for over 600 combinations of engine and aircraft variables. The initial data (Phase I) had TOGW as a dependent variable. A re-direction early in the program resulted in a change to a data base with TOGW as an independent variable (Phase II).

To satisfy the objectives of the program, the following four areas were selected for investigation:

- An alternative to the orthogonal Latin Square (OLS) design selector used in TEVCS/ARES

- Alternate approaches to improve the form of the regression equation

- The effect of the number of independent variables on regression accuracy

- The effect of the number of data points on regression accuracy.

A modified Central Composite Design (CCD) pattern was chosen for the RSTEP study. This design selector provided a convenient means to systematically investigate the impact of the number of independent variables and the number of data points on regression surface accuracy. As part of the study, an analysis was made of the cost of engine and airframe/mission data generation required for the OLS and CCD design selectors. For the number of propulsion variables selected, the results show that the OLS cost of data generation is 2.5 times that of the CCD cost for a five independent variable problem. The OLS cost was almost 1.3 times the CCD cost for nine and ten variable problems.

Four methodologies were studied to improve the form of the regression equation: (1) Transformations, (2) Role Reversal, (3) Indirect, and (4) Optimized Polynomial Exponent. The study results indicate that Transformation methodology provides the single most significant accuracy improvement of all the methods studied, with Role Reversal yielding a further significant improvement. For the Phase I five variable data set, application of Transformation methodology reduced a 34% maximum error of the traditional regression of TOGW to 12% error. The average absolute error was also reduced from 5.8% to 3.6%. The application of Role Reversal methodology with Phase II data made a further significant incremental change in TOGW from 12% maximum error to 7%. The average absolute error was also further reduced to 2% error.

The results of increasing the number of independent variables showed that the TOGW regression accuracy levels for the five, six, and seven variable problems were similar, with a maximum error of less than 10% and average absolute errors of about 2.5%. The 8-, 9-, and 10-

variable problems seemed to form another group with accuracy levels from 12% to 17% for the maximum error, but with only a small increase in the average absolute error to about 3.5%. There were only 3 data points out of over 600 that contributed to errors greater than 12% and these were corner points with limit value combinations of the independent variables.

The results of increasing the number of data points indicate that half replication of the CCD pattern is sufficient for 5- through 9-variable problems, and quarter replication is sufficient for 10-variable problems.

The accuracy of the takeoff distance and landing velocity regressions were excellent, with maximum errors less than 2% even for the 10-variable problem. Combat g-load accuracy was only slightly less, with maximum errors of about 4% and average absolute errors of 1% for the 10-variable problem. The regression error for acceleration time was less than 5% maximum error for 5 through 7 variables, and less than 10% maximum error for 8 through 10 variables. The average error for the acceleration time regression was less than 1.5% for any number of variables.

SECTION I
INTRODUCTION

Advanced weapons system selection and optimization is a complex procedure due to the number and range of airframe, propulsion, and mission variables that must be considered. In response to the Air Force's need, selection and optimization procedures were developed by McDonnell Aircraft Company and the Boeing Aerospace Company under Turbine Engine Variable Cycle Selection Study (TEVCS) (Ref 1) and Airplane Responsive Engine Selection Study (ARES) (Ref 2) contracts. Although these procedures resulted in a significant step forward over the traditional procedures previously used, some of the new procedures represented a first-generation solution to the problem. The TEVCS/ARES techniques did provide a firm base upon which improvements could be built. The Advanced Engine Simulation (AES) (Ref 4) program identified problems in the TEVCS/ARES techniques to evaluate airframe/propulsion systems. These problems are: poor trend predictions, and a need to reduce the cost of generating data for system studies.

RSTEP Task IV is an analytical study to develop regression procedures which will alleviate the problems identified in AES. The specific objective is to identify and evaluate alternate approaches that may be used in TEVCS/ARES procedures to produce system regression surfaces that more accurately reflect the trends of the baseline aircraft design/mission analysis program.

To accomplish these goals, four areas were selected for investigation: (1) the data selection pattern, (2) the form of the regression equation, (3) the number of independent variables and (4) the number of data points. The Central Composite Design (CCD) pattern was selected for this study to provide an alternate to the Latin Square design used in TEVCS/ARES. The CCD pattern also conveniently accommodated the systematic study of increasing the number of independent variables from five to ten; and it accommodated the systematic study of the number of data points. Several alternative approaches to improving the accuracy of the regression equations were also investigated: Transformations, Role Reversal, Indirect Methods, and Optimized Polynomial Exponents. Two of these methods, Transformations and Role Reversal, provided significant improvements in accuracy.

SECTION II
PROBLEM DEFINITION

A. ADVANCED WEAPON SYSTEM SELECTION PROCESS

The process of system definition to meet changing system requirements can be lengthy and can involve large amounts of data. To establish a weapon system which best meets a set of requirements, various configurations must be selected and key design variables established for each configuration. A mission analysis is then performed for each combination of independent variables for each configuration selected, and the capability of each system defined. The capability is then compared to the previously established requirements and figures-of-merit. Iterations for the most promising configuration are performed to refine system capabilty and the optimum variable combinations in the region of defined interest must be determined. With the traditional individual mission analysis approach, it is possible that important variables and interactions between variables may be ignored, resulting in an inferior design.

To meet the need for system selection in a timely, thorough, and flexible manner, the Air Force formulated the Airplane Response Engine Selection (ARES) and Turbine Engine Variable Cycle Selection (TEVCS) programs to develop methodology for computerized system optimization at the airframe/engine independent variable level. This methodology uses statistical approaches for evaluation of the entire independent variable design space to ensure that all variable combinations are investigated and uses a surface fit/search procedure to determine the optimum configuration selection. The Regression Simulation of Turbine Engine Performance (RSTEP) Task IV study is a follow-on study to the ARES program.

B. ARES METHODOLOGY

1. Introduction

The ARES methodology is shown schematically in figure 1. Briefly, the methodology uses a design selector to select independent variable combinations and levels; performance simulators to simulate propulsion system and vehicle performance and determine overall system performance levels; a data interpolator that correlates the system performance output from the performance simulator through the use of regression analysis, and an interpreter that interrogates the performance surfaces that result from the regression equations. The interpreter incorporates optimizer logic that uses a search technique to vary independent variable levels to maximize system performance according to a selected figure of merit. This procedure is described in more detail in the following paragraphs.

2. Description of Methodology

The methodology begins with selection of a given engine type, a given airframe type, given inlet and nozzle types, and a given mission role. For example, the engine type might be a mixed flow afterburning turbofan and the airframe type, a variable sweep wing with podded engines. The inlet might be a two-dimensional, variable ramp, external-compression type. The nozzle might be a variable area ratio convergent-divergent type.

A performance model for each system configuration variable must be created and incorporated into either an airframe/mission analysis computer deck or an engine performance deck. The performance model for each system variable is parametric in the sense that it will define performance for that system element (e.g., afterburning turbofan) for ranges in key independent design variables (e.g., fan pressure ratio variations). Thus, an overall computer model of the system is created that is parametric since design input may be varied.

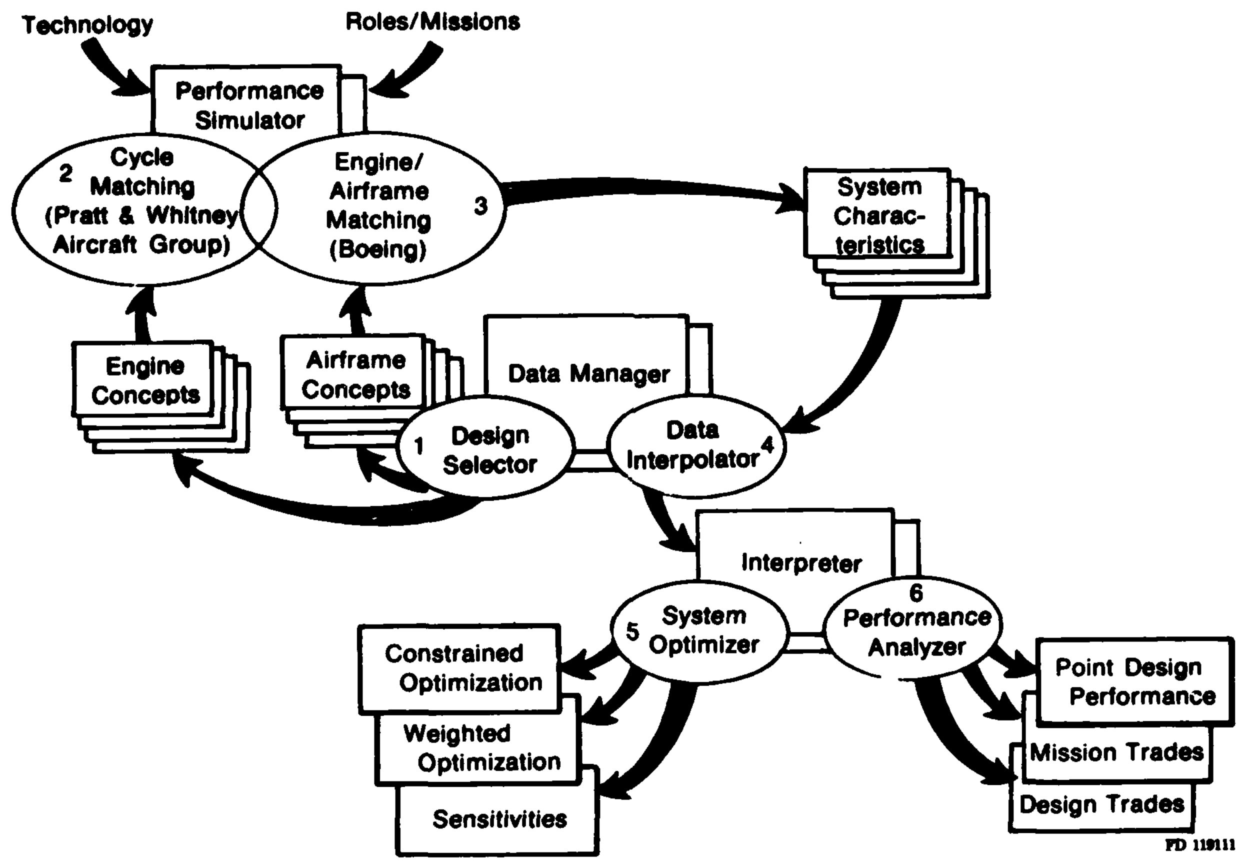


Figure 1. ARES Methodology

Combinations and levels of the key independent design variables are selected for use in defining overall system performance hardpoints. Levels and combinations of both airframe associated design variables (e.g. aspect ratio) and engine associated design variables are selected.

Engine performance data for all mission segments to be included in the mission analysis are generated for all selected engine associated design variable levels and combinations. An airframe/mission deck is then used to establish the system performance levels. The output from the airframe/mission deck, in terms of the dependent variable levels (Take-Off Gross Weight, mission segment operating thrust, TSFC, etc.) associated with the combinations and levels of the independent variables (airframe thrust/weight, cycle overall pressure ratio, etc.) comprise the data base for the ARES methodology. Since the data base includes both engine associated and airframe associated variables, interaction between engine and airframe variables may be studied.

A regression program is used to fit hypergeometric surfaces for any desired dependent variable. The use of the regression equations then permits interpolation of dependent variable solutions for independent variable combinations in addition to those comprising the data base to be determined. Thus, the expanded data base (the regression equations) actually constitute a series of multidimensional surfaces (one for each dependent variable regressed); where the number of dimensions is the number of independent variables in the regression equations. ARES used 2nd order polynomial regression equations for all surface fits.

An optimization program was developed under the ARES program. This optimization program searches the data base to find an optimum engine/airframe design combination by minimizing a specified figure-of-merit (e.g., TOGW) or maximizing a payoff function (mission segment range) subject to constraints on specified functions (e.g., maximum landing velocity). The optimization analysis uses the surface fit functions provided by the regression equations for its payoff and constraint functions. The program incorporates a penalty function technique which incorporates the constraints in the penalty function and a gradient search technique to minimize the penalty function to solve the constrained optimization problem. Any number of optima may be found and analyzed by repeated applications of the procedure with different combinations of constraints and payoff functions. Since this procedure is entirely computerized, the ARES methodology offers rapid assessment of alternative payoff functions, penalty functions, or constraint bands. Also, because the number of variable combinations can be large, the methodology can incorporate both engine and airframe independent variables. Thus, the data base includes engine/airframe interactive effects.

3. Limitations in the Methodology

Experience gained under the ARES and the AES programs has identified accuracy and cost as two dominant limitations of the TEVCS/ARES methodology.

Regression equation accuracy was determined to be the limiting factor in the overall accuracy of the methodology. In some cases, the accuracy level was found insufficient for adequate identification of the optimum independent variables.

The large propulsion data base required for the ARES/TEVCS evaluation process comprises a large part of the total data generation costs. Typically, 400 to 500 points per engine consisting of altitude, Mach number and power setting combinations were generated during the ARES evaluation. The orthogonal Latin Square selection procedure required a minimum of 121 specific engines for a 10-independent variable case (with five propulsion variables) resulting in a requirement of approximately 50,000 engine data points. Based on experience in ARES, the Boeing Company estimated that the propulsion data generation costs comprised 70% of the total.

The ARES/TEVCS procedures tend to be front-end loaded in that a good deal of time and effort can be expended before results become visible. Consequently, it is usually necessary for the engine company to conduct preliminary screening of advanced concepts to identify those that have potential. Avoidance of propulsion system concepts with limited potential is essential to the effective expenditure of resources. It is therefore advantageous to screen new concepts based on a realistic airframe data base during the concept formulation stage.

C. PROGRAM APPROACH

The principal objectives of the RSTEP Task IV study are to identify and evaluate alternative approaches to improve the accuracy of the TEVCS/ARES procedures used for conceptual airframe/engine system design studies, and, to reduce the cost of generating data. Relative to the AES methodology previously discussed, the Design Selector and Data Interpolator procedures are to be studied, and techniques for accuracy improvement and cost reduction are to be identified. In order to satisfy these requirements, four areas were selected for investigation:

- An alternative to the orthogonal Latin Square design selector
- Alternative approaches to improve the equation form
- The effect of numbers of independent variables on accuracy
- The effect of numbers of data points on accuracy.

A modified Central Composite Design (CCD) pattern was selected for this study to provide an alternative to the Latin Square design selector used in TEVCS/ARES. A discussion of this design selector is provided, and a comparison of the data requirements and cost is made with the Latin Square procedure. The CCD pattern provided an economical means to build from a 5-variable problem to a 10-variable problem so that the impact of the number of independent variables could be systematically studied. The CCD pattern also provided a convenient means to investigate the effect of numbers of data points used in the regression analysis for each number of independent variables.

A large number of possible approaches to improve the accuracy of the regression equations was evaluated, including several that are unique to this study. These approaches have been grouped into four methodologies. Each of these methodologies is considered individually, and the improvements attributed to each methodology are identified.

The four methodologies are briefly defined as follows:

1. *Transformation Methodology* — This is the use of functions of a dependent variable (e.g. log TOGW) to provide various amounts of "weighting" to the least squares error function.

2. *Role Reversal* — The role of a variable is traditionally defined as independent if it is an input variable, and dependent if it is an output solution. The Role Reversal technique regresses one of the independent variables as a function of both the dependent variable and the remaining independent variables.

3. *Indirect Methodology* — This method utilizes physically derived relationships in an effort to improve regression accuracy. Usually two or three regression equations are required to define the desired dependent variable in terms of the independent variables.

4. *Optimized Polynomial Exponent* — This method is designed to improve the regression accuracy by determining the best polynomial exponents and order of the cross-product terms.

SECTION III
TECHNICAL DISCUSSION

A. RSTEP VARIABLES AND DATA BASES

Development of the data used in the Regression Simulation of Turbine Engine Peformance (RSTEP) Task IV study was a joint effort by Pratt & Whitney Aircraft/Government Products Division and The Boeing Aerospace Company. A P&WA parametric gas turbine engine cycle matching program was used by Boeing to calculate preliminary steady-state engine performance data for a wide range of cycle variable combinations. Aircraft performance was also calculated by Boeing using the Boeing Engine Airplane Matching (BEAM) program. This work was performed under contract to P&WA.

The P&WA parametric engine computer program used in the RSTEP Task IV study is identical to that used in the Airplane Response Engine Selection (ARES) study, and provides performance and weight estimates for a fixed turbine geometry, mixed flow afterburning turbofan (P&WA computer deck CCD 0234-03.0). Boeing Company provided inlet and nozzle performance characteristics.

The Boeing airplane definition used in the RSTEP Task IV study is also the same as used in the ARES study. This model represents a tactical advanced technology aircraft, with fixed wing sweep, side mounted 2-D horizontal ramp inlets, and conformally carried weapons. The airplane model incorporates 1985 IOC technology throughout. The mission simulated was the same as the supersonic dash interdiction mission used in the ARES study. The mission profile is presented in figure 2. The distance from take-off to the start of dash (and the return from end of dash) was held fixed at 300 nm. For Phase I of the study, the dash radius (RADIUS) was also held constant (100 nm),and the airplane TOGW was a fall-out. For Phase II, the Take-Off Gross Weight, lb, (TOGW) was fixed (an independent variable), and the supersonic dash radius was a fall-out.

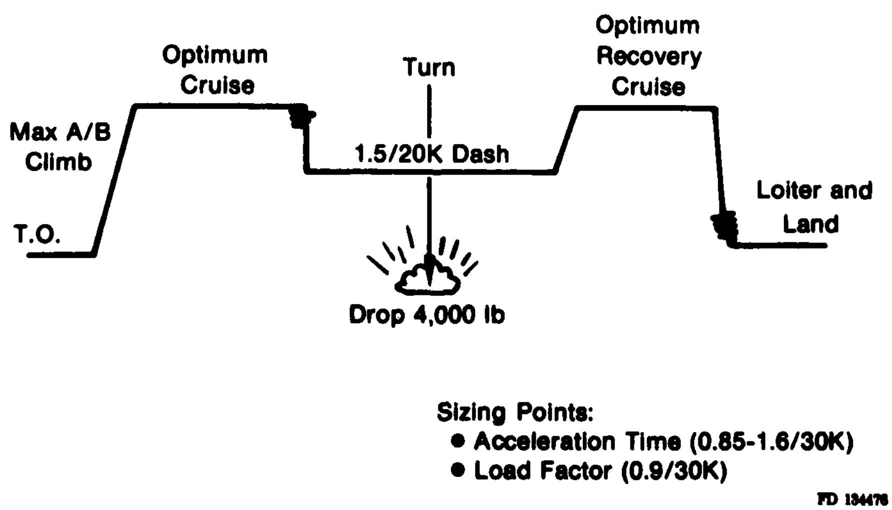


Figure 2. Interdiction Mission

Three data sets will be referred to within the report. Each of the data sets is unique, because each has different independent variables. The first is a data set used in the ARES study. This data set was not used in the RSTEP Task IV study, but is included for comparison. The other two data sets were used in the RSTEP Task IV study, and are referred to as Phase I data and Phase II data. A tabulation of the respective independent variables for these data sets is shown in table 1.

Table I. Independent Variables Used in ARES and RSTEP Task IV

Variable Number	*ARES*	*RSTEP Task IV Phase I*	*RSTEP Task IV Phase II*	*Levels of Variables Studied* Low	Medium	High
1	FPR	BPR	BPR	0.20	1.0	1.80
2	TR	TR	TR	1.00	1.07	1.15
3	W/S	W/S	W/S	80	100	120
4	T/W	T/W	T/W	0.70	1.00	1.30
5	SWP	SWP	TOGW	40,000	60,000	80,000
6	CET		CET	2400	2700	3000
7	AR		SWP	35	50	65
8	A8		A8	−1	0	+1
9	OPR		OPR	20	25	30
10	t/c		AR	1.5	2.5	3.5
TOGW	50,000 lb	Dependent Variable	Variable			
AR	Independent Variable	Scheduled	Independent Variable			
t/c	Independent Variable	Fixed	Fixed			
RADIUS	Dependent Variable	Fixed	Variable			

For the Phase I data, TOGW was selected as the dependent variable for a fixed value of RADIUS. As a result of evaluation of the five variable Phase I data, the decision was made to change the procedure and calculate RADIUS (the dependent variable), and select TOGW as one of the independent variables. The complete study was then made with Phase II data. The decision to change to the Phase II data set was made for the following reasons: (1) It was suggested that RADIUS could be fit more accurately than TOGW, (2) some combinations of independent variables produced unrealistically large TOGW's, or could not converge to a solution, and (3) it takes less computer time to calculate RADIUS for a given TOGW.

Boeing conceived the concept of negative dash radius to provide RADIUS values for all combinations of independent variables. The choice of TOGW as an independent variable turned out to provide additional flexibility and improved regression accuracy as a result of Role Reversal and Quadratic solution methods which were developed in this study.

Although regressions of TOGW and RADIUS received the most attention in this study, regressions of take-off distance (T.O. distance), combat acceleration time (accel time), combat load factor (g-load), and landing velocity (velocity) were also made to determine if any unique problems developed.

A listing of the Phase II data including values of independent and dependent variables is presented in Appendix A.

B. DATA SELECTION PATTERNS

The design selection patterns in common use are described briefly below:

1. Orthogonal Latin Square (OLS)

The TEVCS/ARES procedure uses the orthogonal Latin square method to select independent variable combinations for examination. A detailed description of the OLS procedure

is not presented in this report because this information is available in the TEVCS and ARES reports (Ref 1 and 2). Briefly, a Latin Square is an array of numbers (or objects) which are arranged in such a way that each number appears once and only once in each row and column combination. For the three variable case a cube can be visualized in three dimensions with data points appearing only once in each row/column combination. See figure 3. One advantage of this method is that only a small number of data points are required for large (e.g. 10) numbers of independent variables. One of the disadvantages is that a large number of engines are required in the design matrix; a different engine for each data point. The number of data points is evenly distributed in design space with no possible correlation between variables.

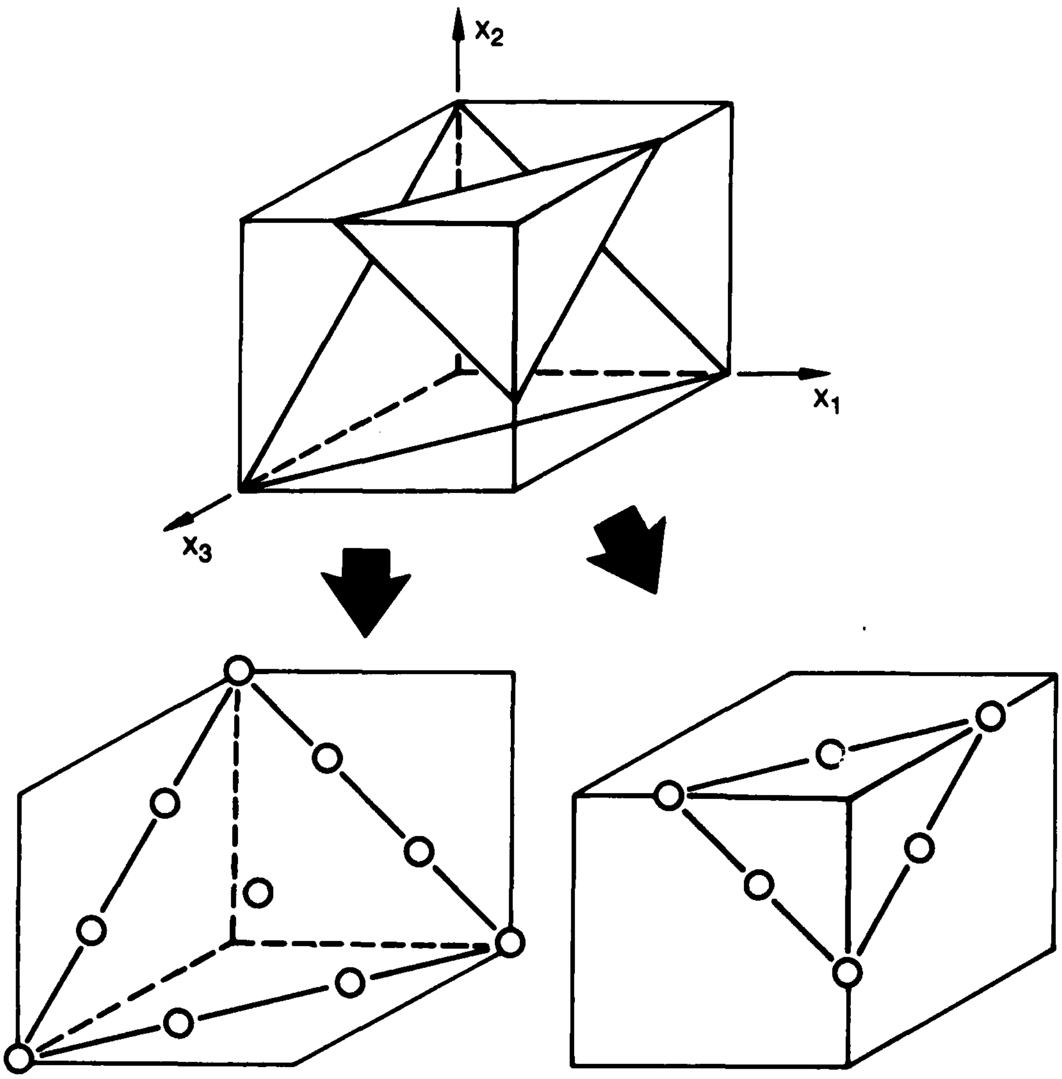


Figure 3. Isometric of Three Variable Latin Squares Pattern

2. AES Experience with Latin Squares

Under Advanced Engine Simulation Study (AES), provision was made to revert to the traditional approach of determining system optimum and its drivers if the accuracy problem was too great, the traditional approach being an evaluation of the figure-of-merit by varying one independent variable at a time. As it turned out, accuracy was a problem, and it was elected to combine the traditional approach with a regression analysis approach based on a variation of the central composite design (CCD) pattern that had been used several times by P&WA in previous system studies. Five of the key independent variables were selected for regression analysis: Fan Pressure Ratio (FPR), Throttle Ratio (TR), Thrust to Weight Ratio (T/W), Wing Loading (W/S), and Wing Leading Edge Sweep Angle (SWEEP). The result was successful, and the trend curves obtained from the regression equations satisfactorily matched those obtained from the data points.

3. Central Composite Design (CCD)

Central composite design patterns in many variations are in common use in response surface methodology. The pattern for a three variable case can be visualized in three dimensions as a cube with a data point at each corner, a point in the center of each face, and a point in the center of the cube, as shown in figure 4.

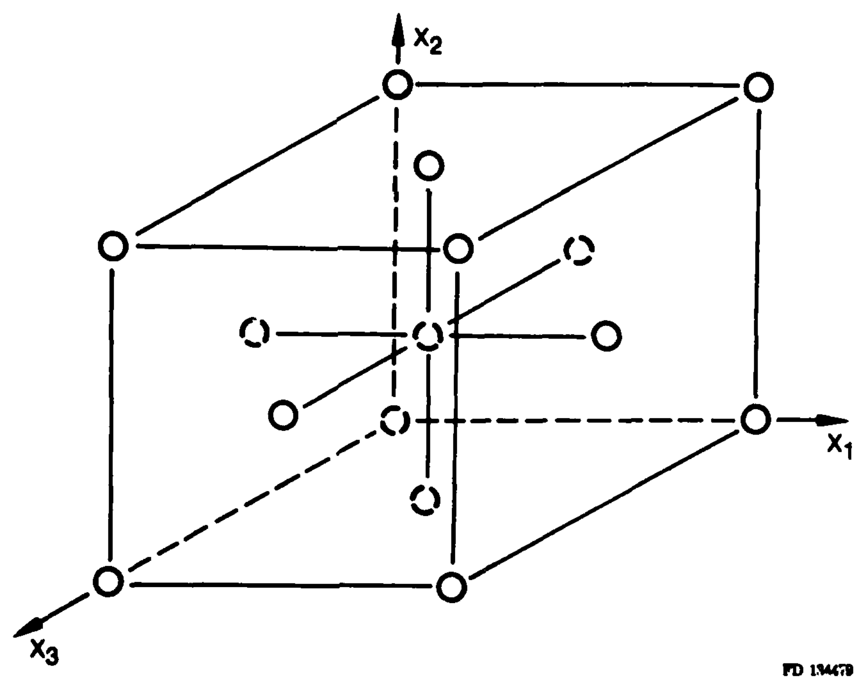


Figure 4. Isometric of Three Variable Central Composite Design Pattern

With this design pattern, many cross-plots can readily be made and cross-coupling terms defined. As the number of independent variables increases, the number of corner points goes up dramatically (2^n), while the number of face points only increases by 2n. It, therefore, becomes

expedient to reduce the number of corner points to reduce the cost of data generation. The equation for number of points becomes:

$$\frac{2^n}{2^k} + 2n = 1$$

for k = 0 all corner points are used (full replication)
k = 1 one-half the corner points are used (half replication)
k = 2 one-quarter of the corner points are used (quarter replication)
k = 3 one-eighth of the corner points are used (eighth replication)

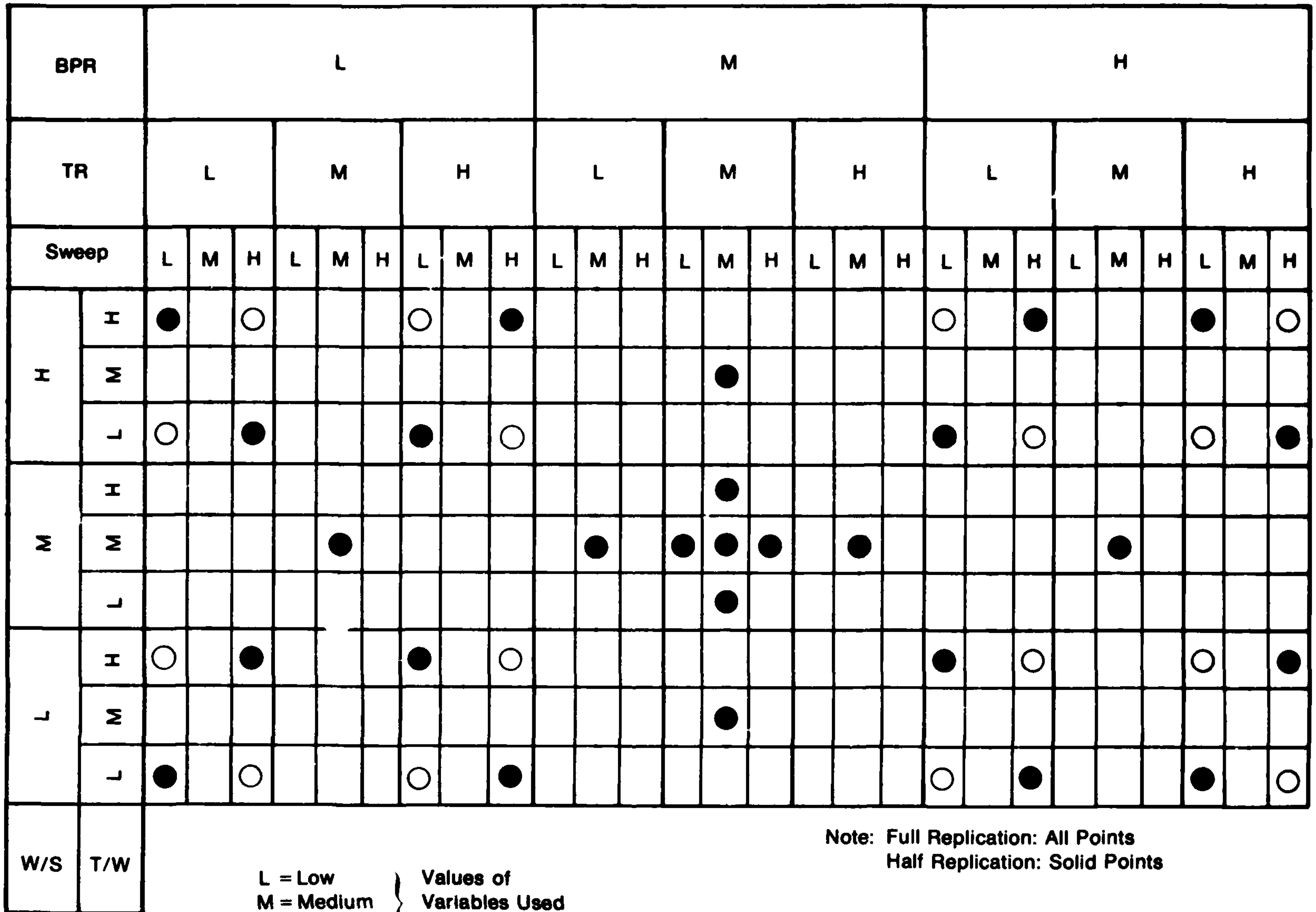
The 5-variable Phase II data pattern is shown in figure 5.

The solid points shown are included in the half replication pattern, while all the points shown are used in the full replication pattern. In data generation, the low (L), mid (M), and high (H) values of a variable are not always the same. At some of the corner points where upper and lower limit combinations of a variable are to be used, a converged solution is not always obtainable. For example, because of constraints built into the parametric engine cycle deck, a 1.6 BPR is the highest (compared to the nominal high of 1.8 BPR) that can be obtained with the high value of throttle ratio and the low value of turbine temperature. Data for the 1.6 BPR engine was substituted for that point, and the value of 1.6 was used for the independent variable (BPR) in the regression analysis. This procedure did not appear to cause any problems in the regression analysis, and allowed generation of all data to meet the pattern requirements.

Table 2 presents the number of data points required as a function of the number of variables for both the CCD and OLS patterns.

The number of points shown for the OLS design results from a criteria that the number of points must be equal to integer powers of prime numbers. For full replication CCD pattern, the number of data points increases significantly for the CCD pattern as the number of variables increases. For this reason, it becomes desirable to reduce replication at high numbers of variables. As the corner points are eliminated, the ability to obtain desired cross plots diminishes and confounding of effects of variable cross products can occur. One of the objectives of this study is to determine the lowest replication which provides acceptable accuracy for each number of variables. A reasonable goal would be to achieve acceptable accuracy with quarter replication of 10 variables.

Even though the required number of data points can be large for a 10-variable problem, the number of engine cycle combinations required would be small. The required number of engine cycles for a given number of engine variables can be obtained from table 2 by interpreting "number of variables" as "number of engine variables" using full replication values. Hence, even with a 10-variable problem, only 43 engine cycle combinations would be required, assuming 5 engine variables. With the current distribution of data cost generation, the 121 points used in Latin squares could be increased to about 400 points for a CCD pattern for the same cost. This greatly improves the pattern density, which is always an advantage.



L = Low
M = Medium
H = High
} Values of Variables Used In Experiment

Note: Full Replication: All Points
Half Replication: Solid Points

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Figure 5. Schematic of Five Variable CCD Pattern

Table 2. Variation of Data Points With the Number of Independent Variables

Number of Variables	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Number of Points:								
Orthogonal Latin Square	16	25	49	49	64	81	121	121
CCD								
full replication (k = 0)	15	25	43	77	143	273	531	1,045
½ replication (k = 1)	11	17	27	45	79	145	275	533
¼ replication (k = 2)						81	147	277
⅛ replication (k = 3)								149
All Possible Interactions (Three Levels)	27	81	243	729	2,187	6,561	19,683	59,049

C. RSTEP TASK IV DATA SELECTION

A modified Central Composite Design (CCD) data selection pattern was selected for use in the RSTEP Task IV study. The CCD pattern offers several advantages for this type of study: (1) defined replication patterns provide a methodical way to study the effects of numbers of data points, and (2) commonality of data points for all variables studied provides a potential cost saving compared to the Latin Squares approach.

Table 3 shows the CCD variable replication combinations selected for study to minimize costs of data generation.

Table 3. Replication Patterns Selected for Study

Numbers of Variables	*5*	*6*	*7*	*8*	*9*	*10*
Full Replication	X	X	X	X		
Half Replication	X	X	X	X	X	
Quarter Replication				X	X	X

The CCD data selection pattern is a fractional factorial design experiment and as such there are fractional replication patterns of the experiment. The fractional replications are defined and can be used to methodically select reduced numbers of data points from within a full data set in order to study the effects of reduced numbers of data upon regression accuracy.

The procedure used in this study was to calculate the 5-variable data set holding all the other independent variables at a fixed value. Then additional independent variables are added one at a time until 10 independent variables have been evaluated. As the number of variables is increased in this fashion, many of the data points that are required for the new variable are common with those calculated for previous cases. This provides economy in data generation as additional variables are added. The advantages of commonality of data points for the CCD pattern can be seen in table 4, which shows the number of data points required for each level of replication of 5 through 10 variables. In addition, the number of points each variable has in common with previous variables is shown in column 2. Column 3 shows the total numbers of data points generated for each variable-replication combination, including those data points that are common to previous results. Data points that are eliminated fall into the category of check points which are data points, excluded from the regression data set, but are available for inspection. One source of these check points is data points left over when half (or quarter) replication of a variable is studied, but full (or half) replication data are available. A progressively larger source of check points is also available as the number of variables is increased because not all points used with

the lesser number of variables is required at the increased variable number level. Values of the independent variables for each check point are substituted into the regression equation to determine the value of the dependent variable for each check point. The value of the calculated dependent variable can then be compared (checked) with the appropriate check data.

Table 4. CCD Pattern Data Point Requirements Variable Build-Up Procedure

Number of Variables, n	Replication	Points Required For CCD	Points Common To Previous Variable	Total Points Generated by Build-Up From 5 Variables	Total Check Points Available
	Full	43	0*	43	0
5	Half	27	0*	43	16
	Quarter	—	—	—	—
	Full	77	33	87	10
6	Half	45	17	87	42
	Quarter	—	—	—	—
	Full	143	65	165	22
7	Half	79	33	165	86
	Quarter	—	—	—	—
	Full	273	129	309	36
8	Half	145	65	309	164
	Quarter	81	33	309	228
	Full	Not Considered			
9	Half	275	129	455	180
	Quarter	147	65	455	308
	Full	Not Considered			
10	Half	Not Considered			
	Quarter	277	129	603	326

*Starting with 5 variable-full replication pattern.

D. OLS VS CCD COST COMPARISON

One of the objectives of this study was to reduce the cost of data generation. Although the orthogonal Latin Square was not directly evaluated as part of this study, an analysis was made of the cost of engine data generation and the cost of BEAM airframe/mission data generation. These results were then used to estimate the data generation costs for the OLS and CCD design selectors.

Table 5 presents the number of data points by type (i.e., numbers of engine combinations and number of independent variables, as used in this study). The number of data points shown for the OLS data selector are the values recommended by Boeing, based on their experience from ARES and other studies. The number of data points shown for the CCD data selector are based on the results of this study, as will be shown in the Presentation of Results. Note that for 5- and 6-variable problems, the OLS design selector requires more data points than the CCD design selector, but at higher numbers of independent variables, the reverse is true. However, in all cases, the number of engine cycles that require data generation is always much less for the CCD pattern. Since the cost to generate engine data is much higher than the cost to generate airframe/mission data, there will be a reduction in the total cost of CCD data generation. At the same time, the CCD design selector provides more than twice the data (for 9 and 10 variables) for potentially improved regression accuracy.

Table 5. Design Selector Case Comparison

Independent Variables			*Orthogonal Latin Squares*			*Central Composite Design*			
Total	*A/C*	*Eng*	*Total*	*A/C*	*Eng*	*Total*	*A/C*	*Eng*	*Notes*
5	3	2	49	49	49	27	15	9	Half Replication
6	3	3	49	49	49	45	15	15	Half Replication
7	4	3	64	64	64	79	25	15	Half Replication
8	4	4	81	81	81	145	25	25	Half Replication
9	4	5	121	121	121	275	25	43	Half Replication
10	5	5	121	121	121	277	43	43	Quarter Replication

Table 6 presents the relative cost of data generation for 10 variable OLS and CCD data patterns. In this example, it can be seen that the cost of the OLS engine data generation is more than the total cost of data generation for the CCD pattern. And, the total cost of OLS data generation is 29% more than that of the CCD pattern. Furthermore, the pattern for the engine data represents full replication data of the engine independent variables; therefore, the engine data itself can be regressed and/or used in other studies with different numbers of non-engine independent variables.

Table 6. Ten Variable Case Cost Comparison Five Airframe, Five Engine Variable

	CCD ¼ Repl	Latin Squares
Number of Engines	43	121
Number of Aircraft	43	121
Total Missions	277	121
Cost of Engine Data	0.44	1.02
Cost of Missions	0.56	0.27
Total Cost	1.00	1.29

Figure 6 presents the total cost of OLS data generation relative to CCD data generation total cost. For 5-independent variables, the OLS cost is 2.5 times the CCD cost. The OLS cost relative to the CCD cost generally decreases with increasing numbers of variables, but at the 9- and 10-variable level, the OLS cost is still 29% greater than the CCD cost.

E. REGRESSION ANALYSIS METHOD

The regression technique employed in RSTEP Task IV is a classical least squares procedure utilizing a pivoting matrix inversion subroutine. This particular computerized regression routine is capable of handling multiple variable, non-integer power, polynomial forms. The routine has backward elimination capability using a t-statistic criteria. Normalization of variables was not used since it was determined that normalization has no impact upon the accuracy of surface fits.

The regression routine was modified and incorporated into a computer program with automated data handling capabilities as a convenience for handling BEAM output and for evaluating methods developed in this study. The capabilities include:

- Transformation and retransformation of dependent variables for both regressed and check data.
- Calculation of quadratic solutions for independent variables from 2nd order polynomial regression equation forms.

- Error statistic analysis for indirect methods that use regressed variables as independent and dependent variables.

A sample computer printout from this routine is presented in Appendix B for a 7-variable half replication case.

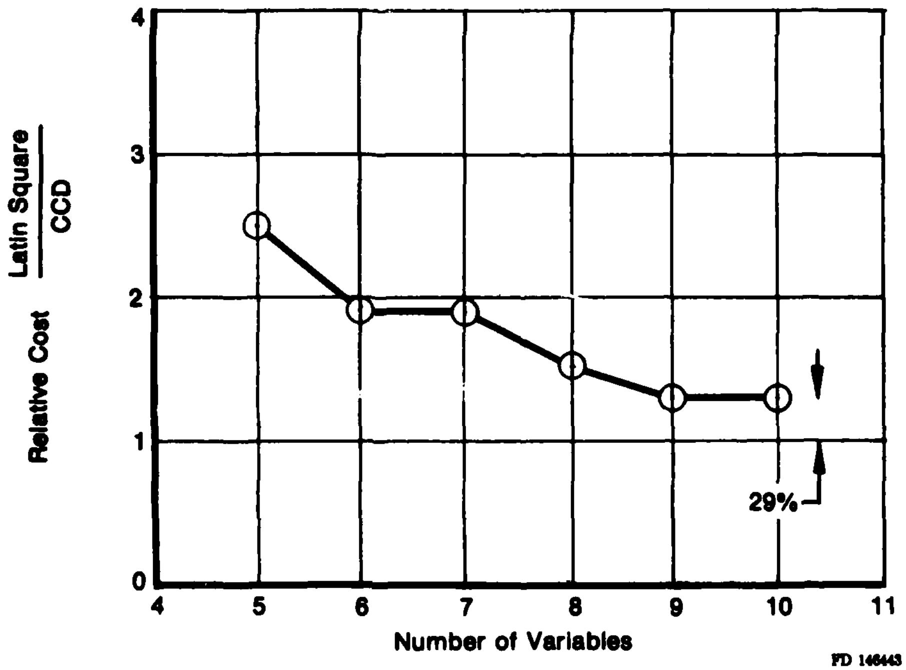

Figure 6. Relative Data Generation Cost Comparison

SECTION IV
DISCUSSION OF TECHNIQUES

A. TRANSFORMATION METHODOLOGY

1. Transformation Development — Phase I Data

The first and most important of the five methodologies presented is the Transformation method. Transformation methods, as defined in this report, utilize functions of the dependent variable (e.g. log TOGW) to obtain better regression surface accuracy. Transformations of this type are equivalent to regressing a dependent variable in terms of multiple order, multiple term power functions. Although use of this method is not new, the interpretation of the use of the transformations and the development of a parametric family of transformations is believed to be unique to this study.

As noted previously, the study utilized two data sets, Phase I data and Phase II data. Transformation methods have been applied to both data sets, although the development of the systematic approach was evolved during the study of Phase I data.

Five engine/aircraft variables were considered in Phase I. Traditional least squares quadratic regression of the dependent variable TOGW as a function of Wing Loading (W/S), Bypass Ratio (BPR), Throttle Ratio (TR), Thrust to Weight Ratio (T/W), and Leading Edge Sweep Angle (SWEEP) resulted in errors greater than 30%. For dependent variables that have a wide range of values over a design region, the least squares procedure tends to result in smaller percentage errors at large values and larger percent errors at small values. This happens because the least squares procedure minimizes the sum of the squares of the differences and not the sum of the squares of the percent differences. As shown in figure 7, the difference between observed and regressed values (Δ TOGW) varies over a wide range (45k → 153k) of values of TOGW. Transformations of the dependent variable can be used to produce a more uniform percentage error distribution over the range of values of a dependent variable; or, to improve the accuracy of either the small or large value end of the dependent variable range. One method of interpreting transformations is to consider them as analogous to providing various amounts of weighting to the least squares error function. This is not to be confused with the classical weighting function normally used in regression analysis.

If, for example, we examine function $y = \log(\text{TOGW})$, the differential of this function is given by $\Delta y = \Delta\,\text{TOGW}/\text{TOGW}$, the criterion of least squares minimizes an error function $(\Delta y)^2 = (y_{observed} - y_{calculated})^2$. Because of the log transformation, minimizing the sum of $(\Delta y)^2$ is analogous to minimizing the sum of the squares of percent error of the original dependent variable, TOGW. The log transformation, in effect, "weights" the error differences (ΔTOGW) by the inverse of the value of the dependent variable. This tends to improve the fit at low values of the dependent variable. The improvement in the fitting of the Phase I TOGW dependent variable using the log transformation is shown in figure 8. For all cases where transformations are used, the figures-of-merit for the regression accuracy are based on the error in the untransformed values of the dependent variable. Comparison of these data with the untransformed data shows that the maximum percent error is significantly reduced and the percent error for all the data is improved.

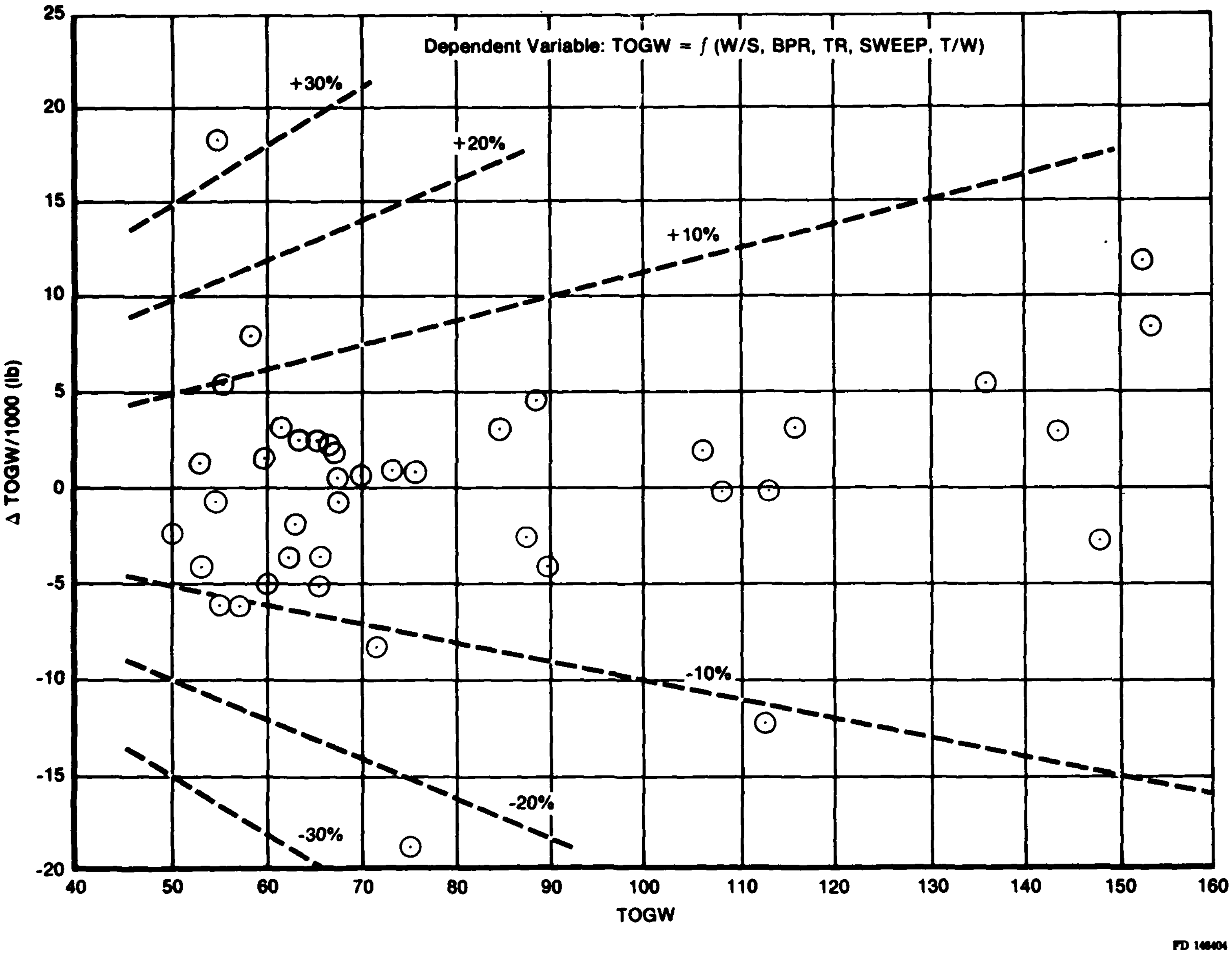

Figure 7. Distribution of ΔTOGW for Conventional Regression

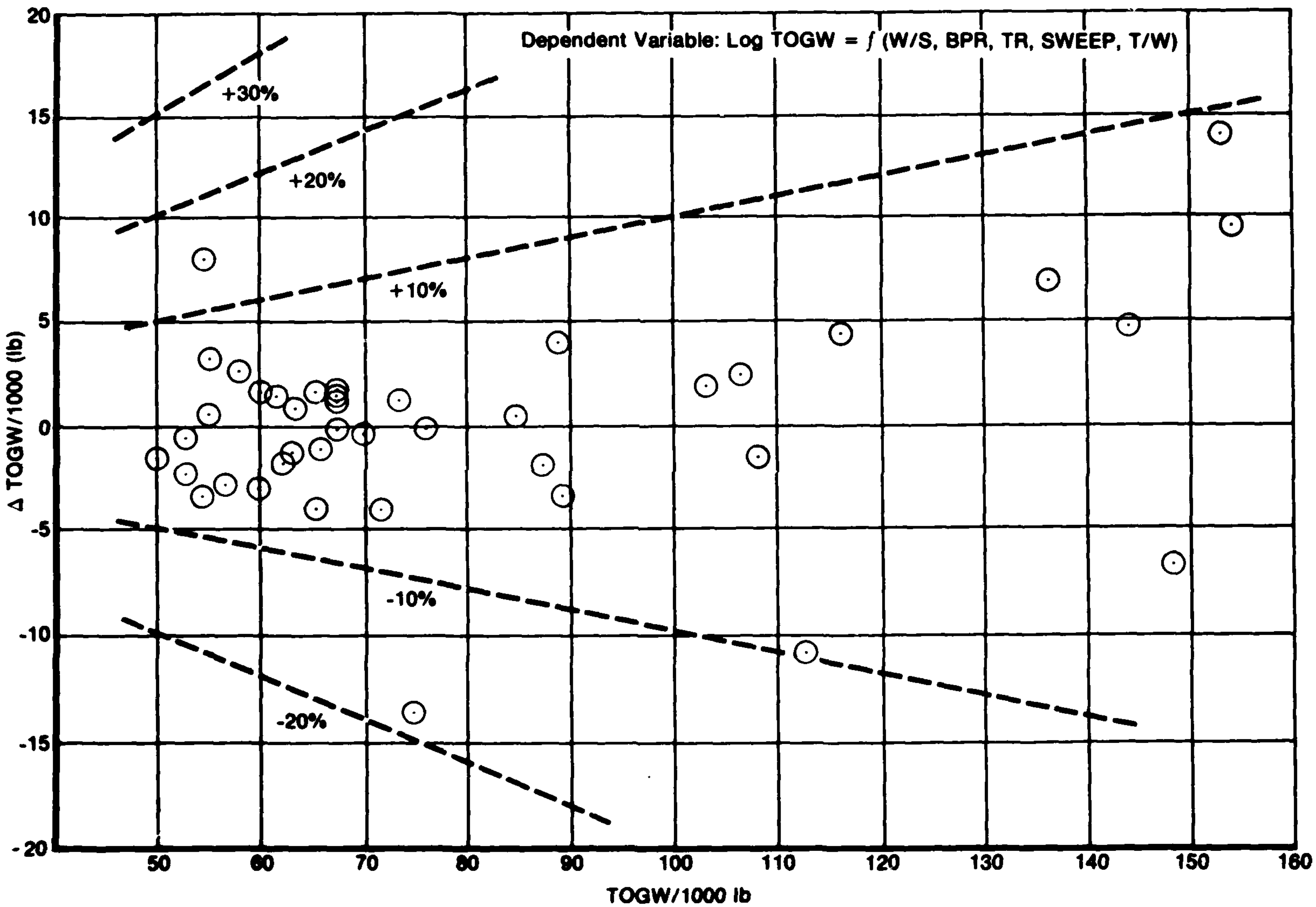

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Figure 8. Distribution of ΔTOGW for Log Transformation Regression

Closer examination of the differential form shows that a family of transformations can be defined which have different "weighting" effects on the error differences. In general, the differential form of the dependent variable can be defined as $\Delta y \; \alpha \; (\Delta \text{ TOGW}) \text{ TOGW}^N$, where N is defined in this report as the derivative exponent. Thus for the log transformation $N = -1$, and the N for the untransformed case is, by definition, equal to zero. Figure 9 presents the family of transformations derived using TOGW as an example of the dependent variable. Note that for $N < 0$, only dependent variables with values greater than zero can be considered for transformation. In practice this can be overcome by adding a constant to all dependent variable values to produce positive values.

The dramatic effect of using transformations of the dependent variable can be seen in figure 10. In this study, the selection of the transformation $y = \text{TOGW}^{-1}$ (i.e., the derivative exponent = -2) results in the largest reduction in the maximum percent error (from 30% to 11.9%), while reducing the average error as well. For comparison with the two previous error distribution curves, figure 11 shows the error distribution for the inverse transformation. As shown, the errors of prediction in the region of most interest (lower values of TOGW) are, in general, lower than those of the conventional untransformed regression results. In addition, lower percent errors were obtained over the entire range of TOGW values considered.

The generalized development of transformations does not preclude their use for other dependent variables. Transformations have also been used to improve the regression accuracy of takeoff distance and combat acceleration time. Figures 12 and 13 show the dramatic improvement in maximum and average percent errors of each of these variables for a range of derivative exponents. While transformation methodology has shown significant accuracy improvement for these variables, some variables such as combat g-loading and landing velocity had excellent fits without transformations (i.e., $N = 0$). As shown, transformations of TOGW data enabled us to substantially reduce prediction error for Phase I data. However, the resulting errors were still higher than desirable considering that only five independent variables were used.

General Form: $\Delta y \alpha \; (\Delta TOGW) \; TOGW^N$

Transformation	*Differential Form*	*Derivative Exponent, N*
$y = \text{TOGW}^2 = f$ (Independent Variables)	$\Delta y \alpha \; (\Delta \text{TOGW}) \; \text{TOGW}$	+1
$y = \text{TOGW} = f$ (Independent Variables)	$\Delta y \alpha \; \Delta \text{TOGW}$	0
$y = \log (\text{TOGW}) = f$ (Independent Variables)	$\Delta y \alpha \dfrac{(\Delta \text{TOGW})}{\text{TOGW}}$	−1
$y = (\text{TOGW})^{-1/2} = f$ (Independent Variables)	$\Delta y \alpha \dfrac{(\Delta \text{TOGW})}{\text{TOGW}^{1\frac{1}{2}}}$	−1½
$y = (\text{TOGW})^{-1} = f$ (Independent Variables)	$\Delta y \alpha \dfrac{(\Delta \text{TOGW})}{\text{TOGW}^2}$	−2

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Figure 9. Transformations of TOGW

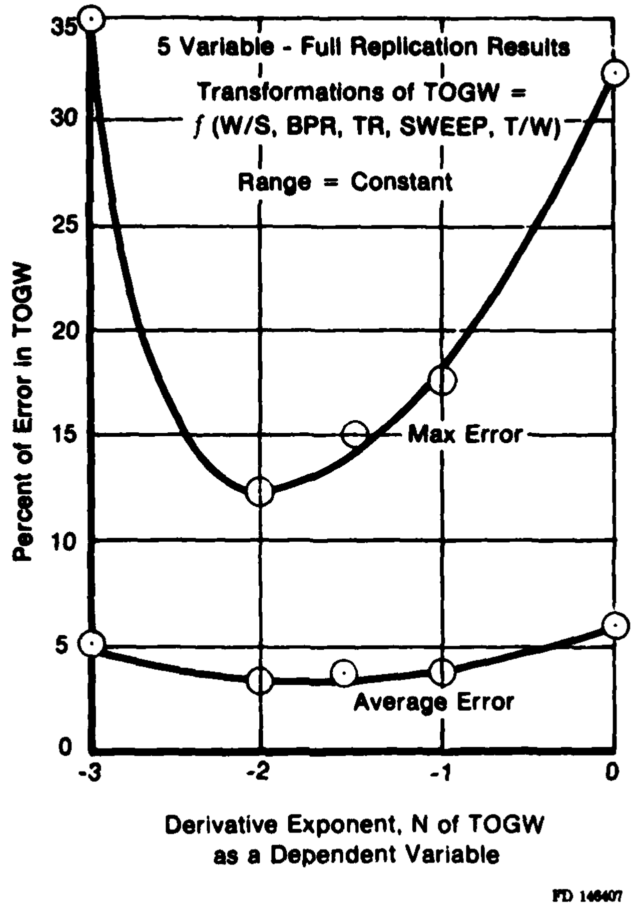


Figure 10. Effect of Transformations on TOGW as a Dependent Variable

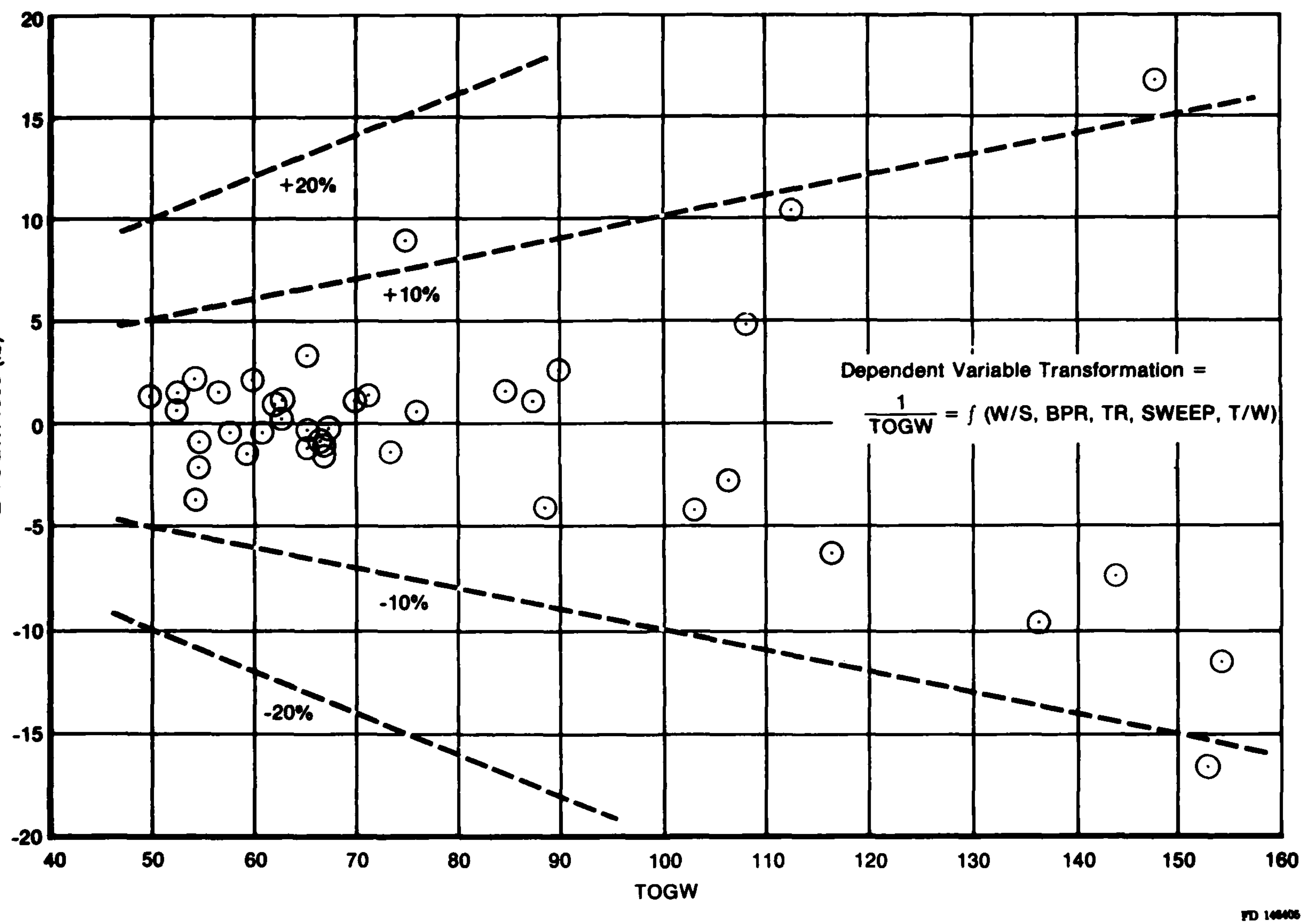


Figure 11. Distribution of ΔTOGW for the Inverse Transformed Variable

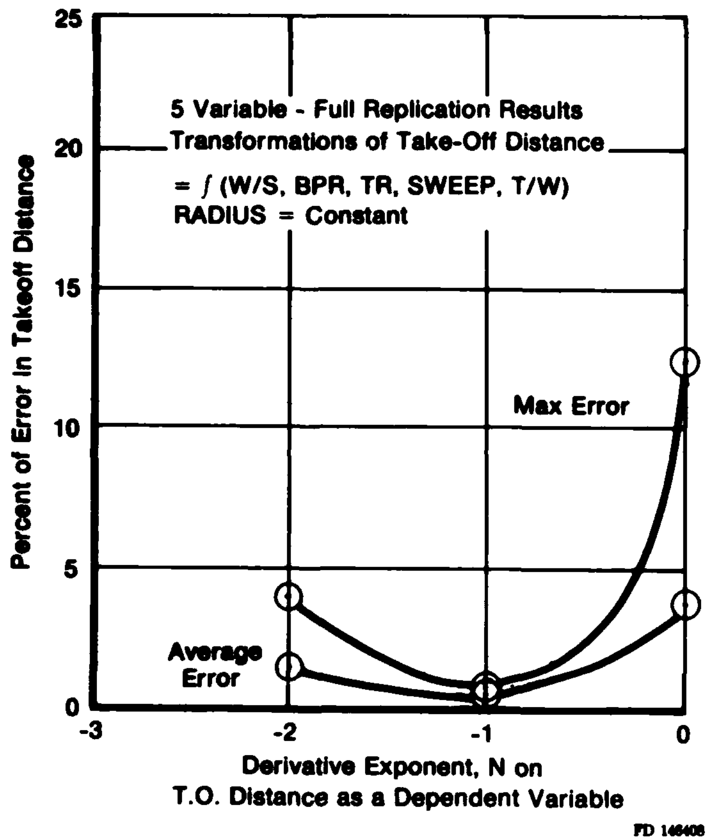


Figure 12. Effect of Transformations on Takeoff Distance as a Dependent Variable

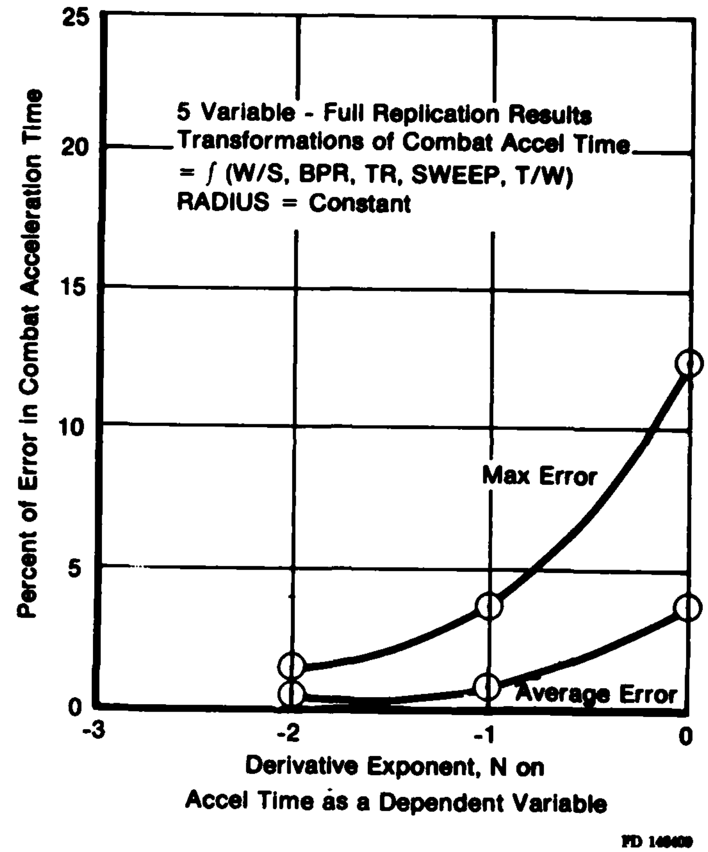


Figure 13. Effect of Transformations on Acceleration Time as a Dependent Variable

2. Transformations — Phase II Data

a. RADIUS as a Dependent Variable

RADIUS as a dependent variable presents several problems. First, not all combinations of independent variables provide a positive dash radius. Therefore, Boeing Company conceived the concept of negative dash radius. Although this is mathematically correct, it has no physical meaning. This concept of negative dash radius provides a continuous surface to fit and provides sufficient data to complete the data selection pattern. This concept was also used previously in the ARES study.

Total mission RADIUS was regressed for RSTEP in order to apply the transformation methods (i.e., Radius > 0), but actual delta dash radius statistics were used for the figure-of-merit. The results are shown in figure 14. It is not clear from these results that regressing RADIUS is more accurate than regressing TOGW as was done with the Phase I data. This comparison will be addressed further in the following section.

b. Quadratic Solution

A method for evaluating the regression accuracy of RADIUS as a dependent variable can be obtained by observing that the regression equation form used is quadratic and that an exact closed form solution exists for any one of the independent variables in terms of the other variables.

$$\text{RADIUS}^* = f\,(\text{TOGW, ------}) \qquad \Big\{\text{Quadratic Equation}$$

$$\text{TOGW} = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \qquad \Big\{\text{Quadratic Solution}$$

NOTE: *May be transformed function.

Hence, TOGW can be obtained by Quadratic solution of the regression equation for RADIUS. Observed values for RADIUS can be substituted into this equation and TOGW calculated and compared with known values. This method also has the advantage of being able to solve the problem of determining minimum TOGW for a given Radius requirement.

Combining the Transformation and Quadratic solution methodologies we find in figure 15 that the best transformation provides a maximum error of 11.8% and a 3.4% average percent error. Note that this error is similar to the 11.9% max percent error and 3.6% average error result from the Phase I data.

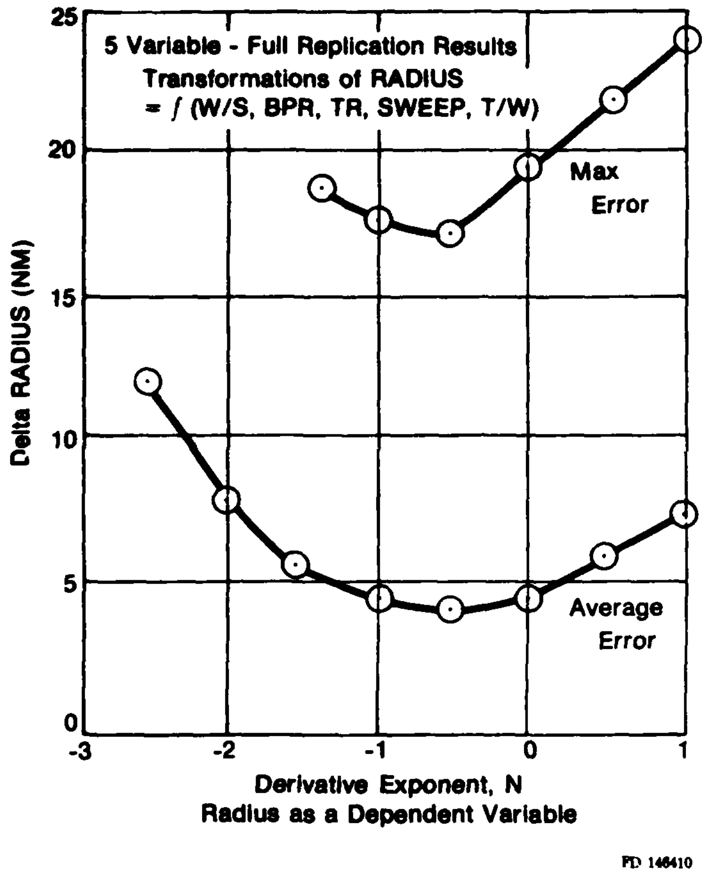


Figure 14. Effect of Transformations on RADIUS as a Dependent Variable as a Function of Five Variables

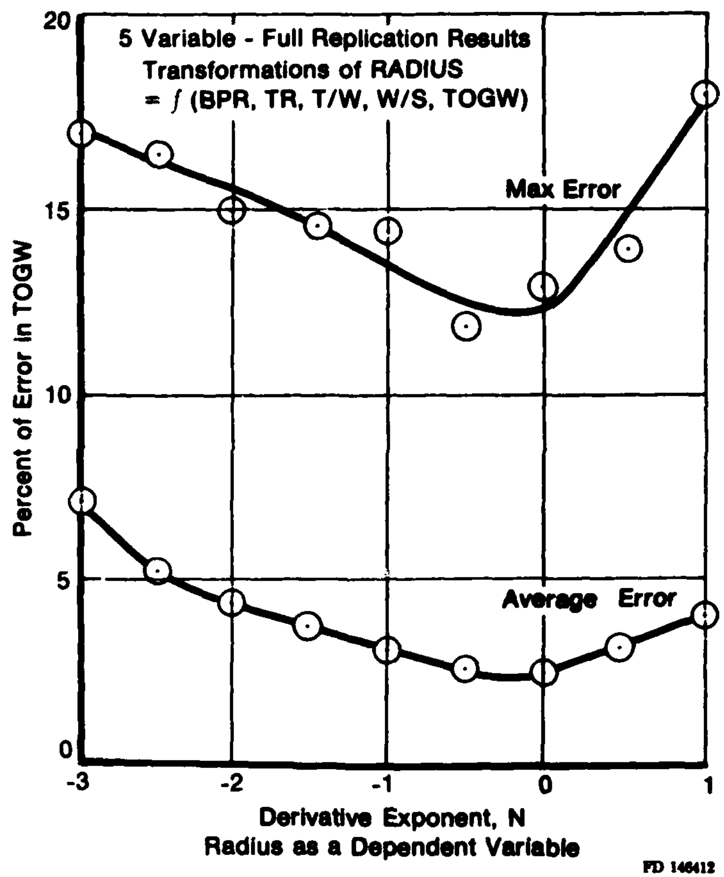


Figure 15. Effect of Transformations on TOGW Calculated by Quadratic Solution of RADIUS as a Function of Five Variables

B. ROLE REVERSAL METHODOLOGY

An alternative method for using the Phase II data base is to apply a method defined in this report as Role Reversal. The Phase II data set chosen for study uses TOGW as a mission input (independent variable) with RADIUS as an output (dependent variable) of the mission calculation. The traditional approach is to regress RADIUS (dependent variable) as a function of TOGW and the other independent variables. This approach would address the question of predicting RADIUS for a given TOGW. A problem of greater interest is to predict TOGW for a given RADIUS. For this problem it would be more convenient to use TOGW as the dependent variable and RADIUS as the independent variable. Thus, the Role Reversal methodology is to reverse the roles of these two variables, and regress TOGW as a function of RADIUS, W/S, BPR, TR, etc. .... Comparison of regressed values of TOGW with the hard point data input to the mission simulation becomes the figure-of-merit. The Role Reversal methodology combined with transformation methods described previously has proved to be effective in improving TOGW regression accuracy.

The improvement in regression accuracy using the Role Reversal technique for TOGW as compared to the quadratic solution for TOGW from Radius regressions is shown in figure 16. Transformations combined with Role Reversal methodology reduce the maximum percent error from 12% to 7% and reduces the average percent error from 3.5% to 2%. Observe that the most effective transformation for Role Reversal combined with Transformation methodologies is the log (TOGW). This differs from the reciprocal transformation shown to be the best for the Phase I data.

An interesting side result of using Role Reversal occurs when the quadratic solution is applied to the TOGW regression equation (in which Role Reversal was used), and RADIUS is calculated. This result is shown in figure 17 along with the result for direct regression of RADIUS. The RADIUS prediction by Role Reversal and Quadratic solution is significantly more accurate than direct RADIUS regression. The implication here is that the TOGW surface can be regressed more accurately than the RADIUS surface.

A summary of the accuracy improvements provided by the Transformation and Role Reversal Methodologies is presented in figure 18. Case A, the untransformed baseline, had a very large maximum error of 33.6%. Case B is the result of applying the best TOGW transformation. It yielded a reduction in maximum error from 33.6% to 11.9%, and a reduction in average absolute error from 5.8% to 3.6%. A shift to Phase II data which had TOGW as an independent variable permitted application of Role Reversal methodology. Case C represents the best radius transformation regression, with TOGW being calculated by quadratic solution. This yields results very similar to the Phase I transformed data. Case D has Role Reversal applied, and further improvement in accuracy is achieved.

C. INDIRECT METHODOLOGY

1. Discussion of Methodology

Another approach studied as part of this contract utilizes physically derived relationships in an effort to improve regression accuracy. Variables such as fuel fraction, propulsion fraction, engine diameter, and engine length are used as independent variables in the regression of RADIUS, TOGW, etc. The method is termed indirect because the physically derived variables are first regressed in terms of the basic 5 through 10 design variables. Then, the equations of these variables are used to supply input for calculating dependent variables such as TOGW from a regression equation containing the physically derived variables.

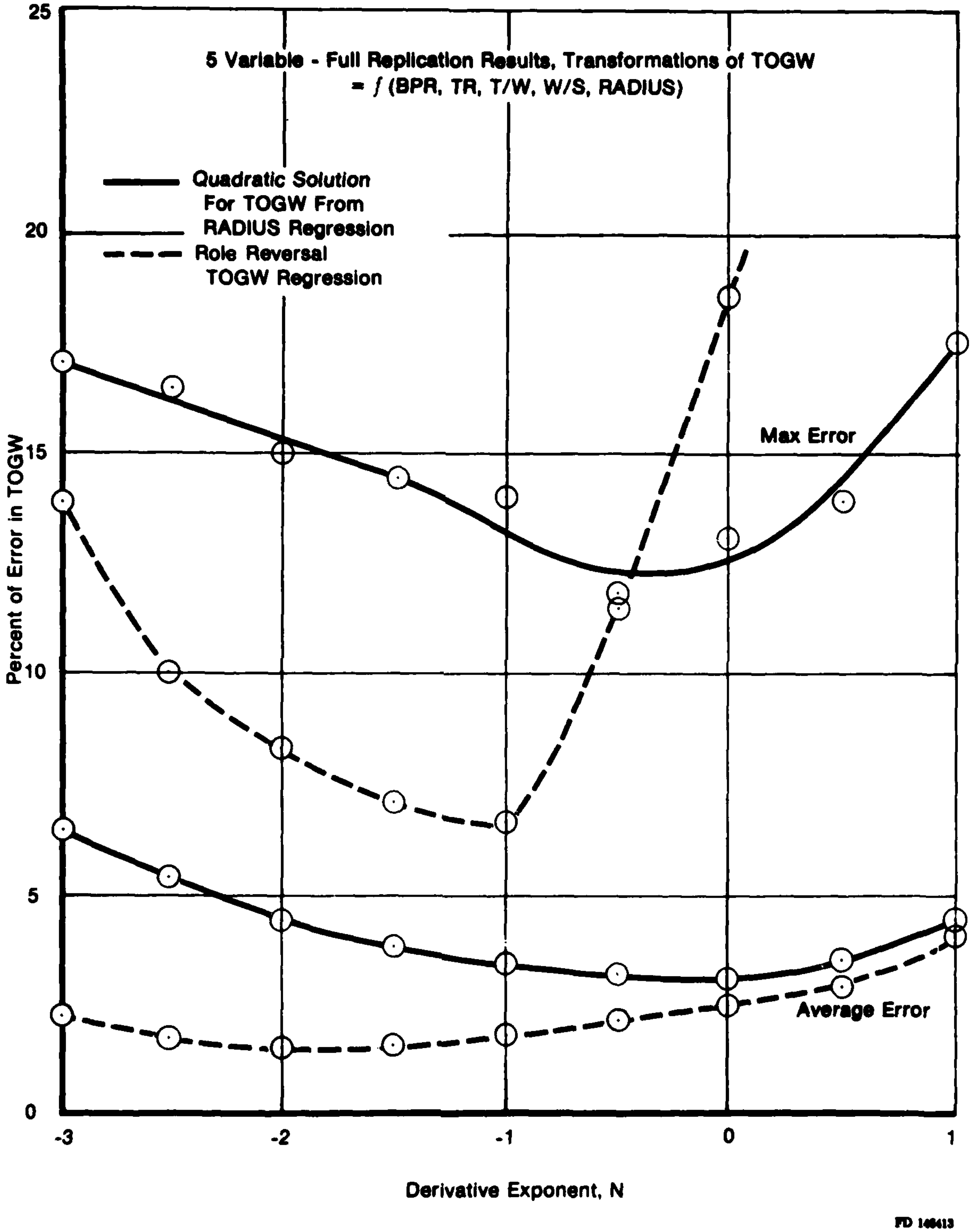


Figure 16. Effect of Role Reversal on Regressed Values of TOGW as a Function of Five Variables

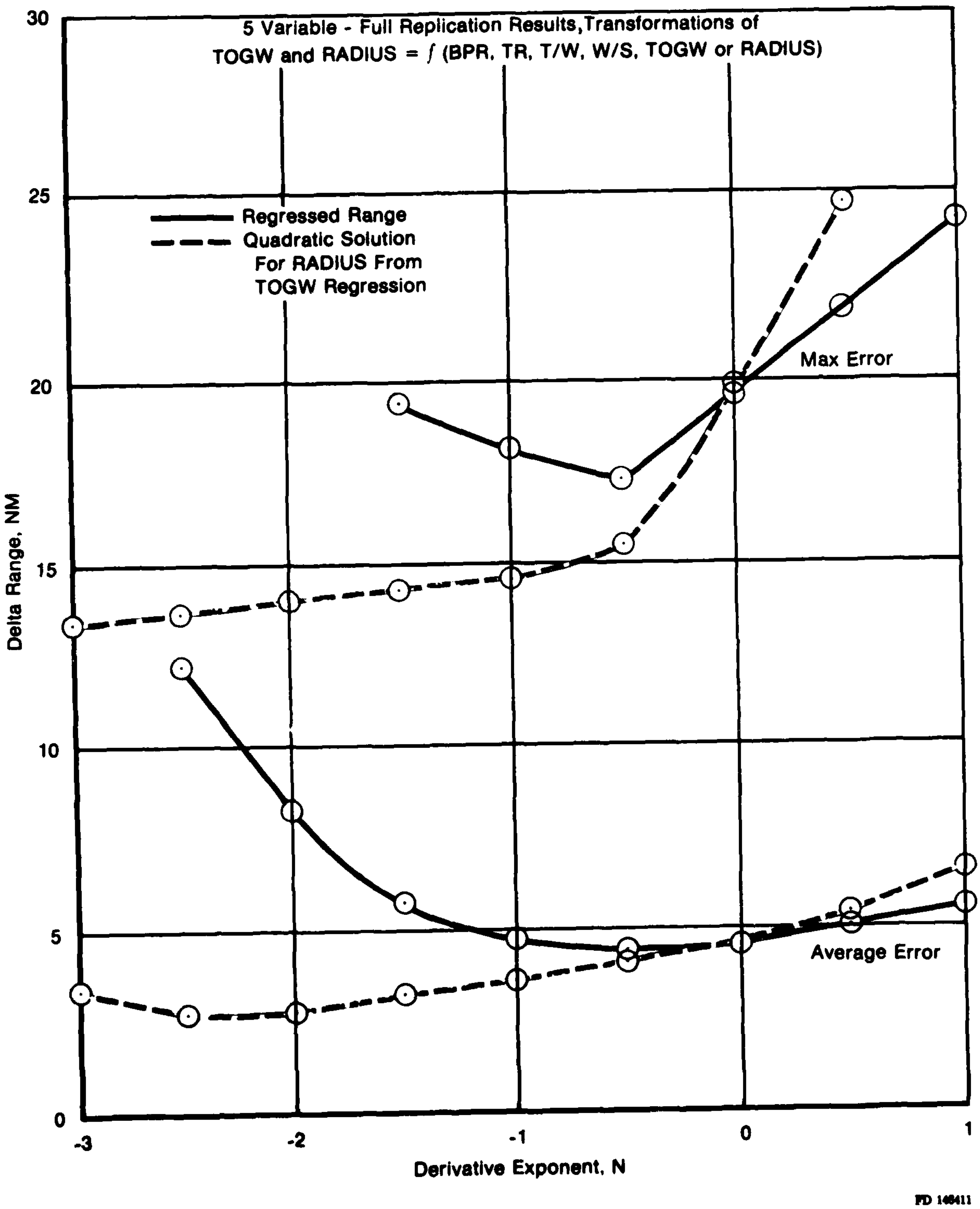


Figure 17. Comparison of RADIUS Errors — Regressed Range vs Quadratic Solution for Range from a Five Variable Regression of TOGW

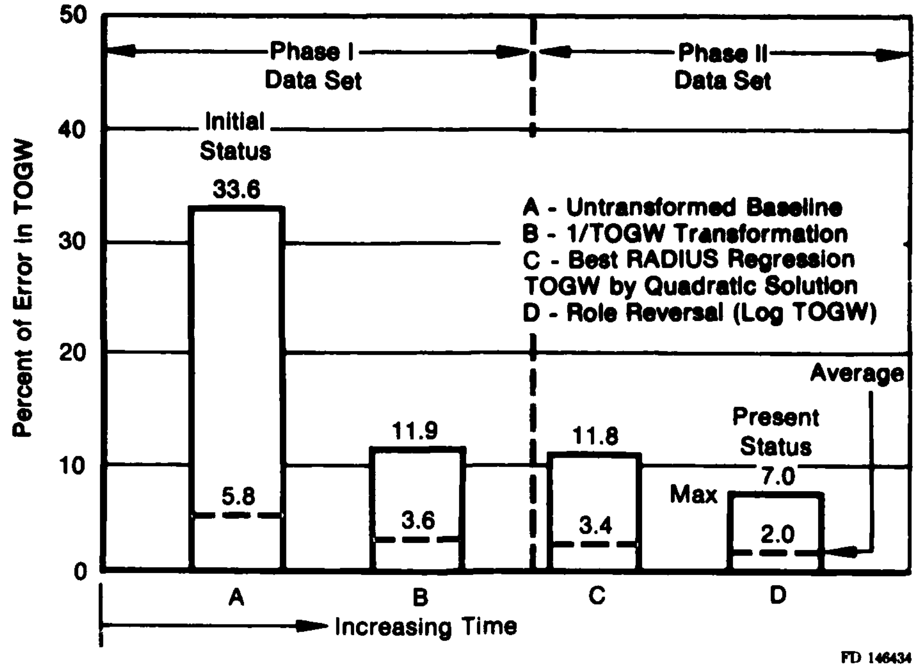


Figure 18. Impact of Transformation and Role Reversal Methodologies on Regression Accuracy — Five Variable Regression

This method has not been shown to provide significantly better regression accuracy compared to more direct methods even when Transformation and Role Reversal methodologies are applied.

2. Phase I Data Results

The approach taken is based on the characteristic relationship of TOGW as a function of propulsion plus fuel weight fractions instead of engine cycle variables. The propulsion and fuel weight fractions can be regressed separately as a function of the engine cycle and aircraft variables.

Results for indirect regression of TOGW for the 5 variable case are presented in figure 19 to illustrate the methodology. As shown, the histogram is divided into the best results for Phase I data using direct regression of TOGW (IA) and two indirect regressions of TOGW. The result represented by IB utilizes the sum of fuel and propulsion fractions and engine length and diameter as independent variables (in addition to W/S and SWEEP) as shown below:

$$TOGW^{-1} = f\left(\frac{W_{fuel} + W_{propulsion}}{TOGW}, \text{Diameter, Length, W/S, Sweep}\right)$$

Regressed values for the physically derived variables, W_{fuel} + $W_{propulsion}$/TOGW, engine diameter, and engine length (obtained from the best transformation fits) are substituted into a regression equation for TOGW obtained by fitting only observed values for the basic and physically derived variables in order to determine the error in predicting TOGW. As shown in figure V-13, the approach represented by IB results in maximum and average absolute percent errors considerably greater than the direct approach IA.

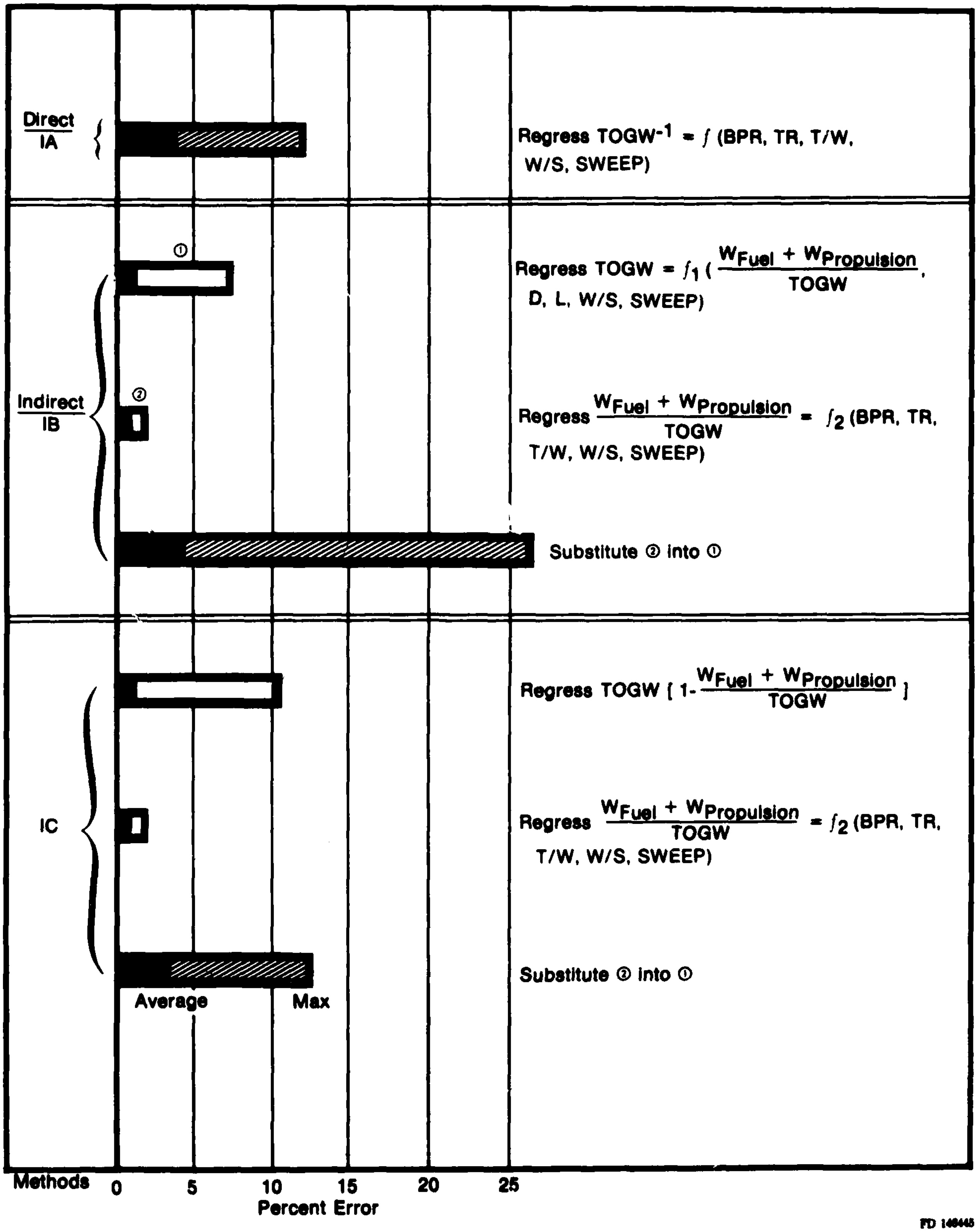


Figure 19. Summary of Indirect Methods for Phase I Data

The second approach to the indirect method, IC, utilizes the physically derived relationships in the dependent variable rather than as an independent variable as shown below:

$$\text{TOGW}\left(1 - \frac{W_{fuel} + W_{propulsion}}{\text{TOGW}}\right) = f\,(\text{W/S, BPR, TR, T/W, SWEEP})$$

for determining the TOGW error, regressed value of fuel plus propulsion fraction were used.

Very good accuracy (maximum error ~ 1.5%) was obtained for the regression of fuel plus propulsion fraction as a function of the basic, five independent variables (BPR, TR, W/S, T/W, SWEEP). The good fit indicates that the fuel plus propulsion fraction is a fundamental parameter. However, regression of the function

$$\text{TOGW}\left(1 - \frac{W_{fuel} + W_{propulsion}}{\text{TOGW}}\right)$$

resulted in about 10% maximum error , yielding a combined error of 12% for TOGW,as shown in figure 19. These results show that the indirect methods utilizing physically derived relationships yield regression accuracies about the same as direct regression. However, the possibility remains that another variation of Indirect methods could provide improvement.

3. Phase II Data Results

The approach taken with the Phase II data with Radius as a variable was to regress TOGW as a function of some form of fuel fraction (W_{fuel}/TOGW) rather than RADIUS as an independent variable. Once a regression equation for TOGW is obtained, then the second step is to regress the form of fuel fraction as a function of RADIUS (and BPR, TR, T/W, and W/S for a five variable case). The third step is to calculate values for the appropriate form of fuel fraction from step two and substitute them into the step one equation for TOGW.

The first attempt at this process quickly yielded promising results. By regressing the following equation:

$$\text{TOGW}^{-1} = \left(\frac{W_{fuel}}{\text{TOGW}}\text{, BPR, TR, T/W, W/S}\right),$$

it was found that the maximum percent error in TOGW was only 0.9%. Three other variations in the form of fuel fraction were also tried in order to further improve this result.

Results of regression analysis of TOGW using these variations are shown in figure 20. This figure summarizes the Phase II indirect methods results, and compares the results with direct regression of TOGW, method IIA. (The steps required to solve for TOGW are shown) for each method presented. The first results are shown as method IIB. As shown, the error in magnitude of 3.0% of fuel fraction is not good enough because TOGW is very sensitive to fuel fraction. Method IIC produced an improvement in fuel fraction prediction by applying a TOGW correction factor to the fuel fraction to account for size effects on the aircraft drag. The coefficient, 0.15, was obtained by parametric optimization. Overall results for IIC show no overall improvement over indirect method IIB. Method IID is another variation on fuel fraction form. The log form used for the fuel fraction was derived from the Breguet range equation. The overall effect of IID produced a small improvement in accuracy over IIC, but still not as good as IIB.

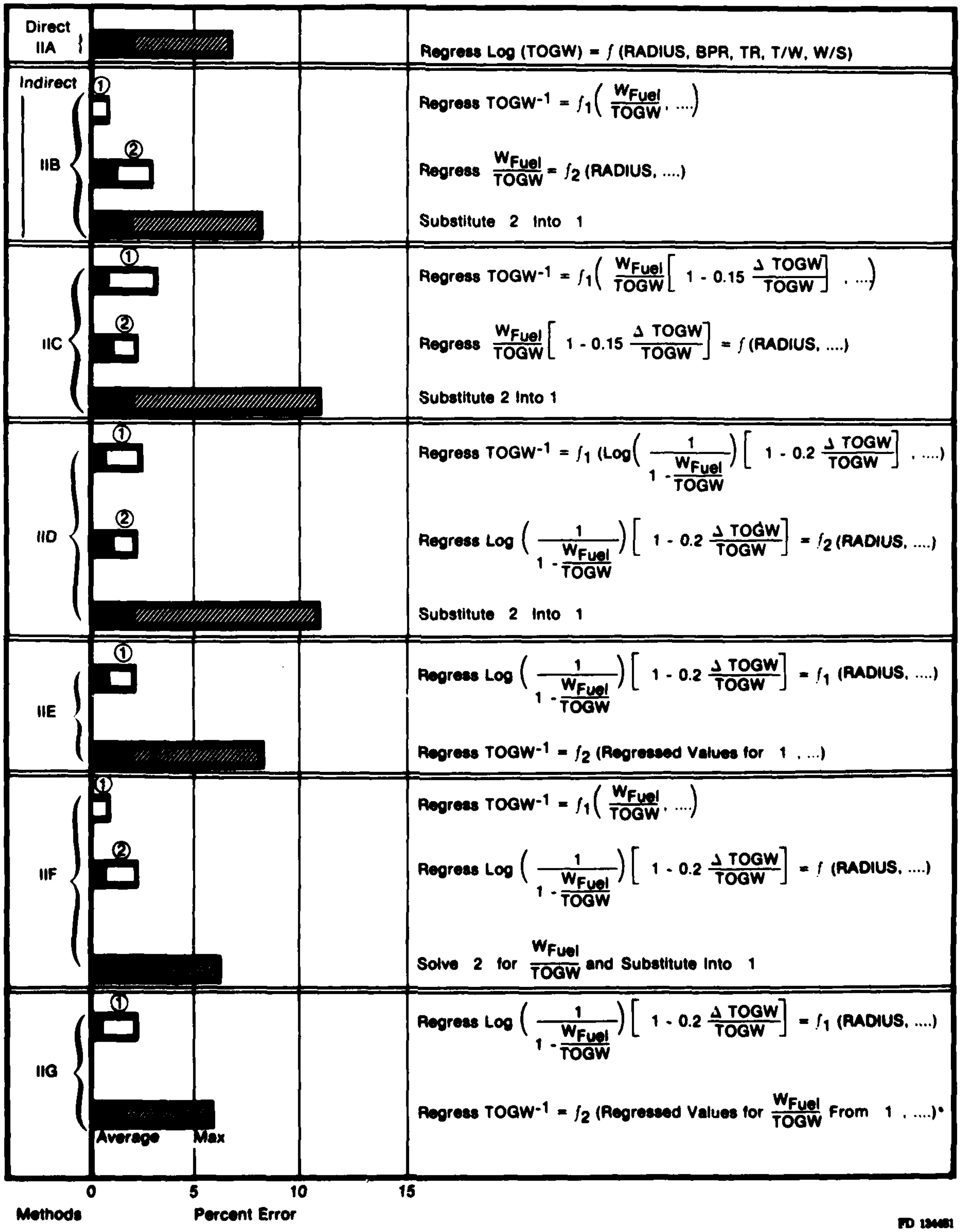


Figure 20. Summary of Indirect Methods for Phase II Data

Of all the methods examined, method IIG offers the best accuracy of the indirect methods, but it is only marginally better than the direct method, IIA. Note that the indirect methods that incorporate TOGW correction factor (ΔTOGW/TOGW) to the fuel fraction (such as IIG) are actually transcendental and the solution presented is based upon the first estimate for TOGW in the correction term being equal to the observed value of TOGW. The approximation is reasonable since the term represents a small correction to the fuel fraction. A rigorous solution would require an iterative procedure. It is probably doubtful that the small improvement offered by the best indirect method over the direct regression is worth the added complication in the calculating procedure.

D. OPTIMIZED POLYNOMIAL EXPONENT METHODOLOGY

The Optimized Polynomial Exponent method is designed to improve the surface fits by determining the best form and order of the combined polynomial and cross product regression equation terms. A computerized program was assembled from existing subroutines to determine the exponents of each of the elements of the terms of a generalized regression equation by a stochastic search and optimization process; and, to determine the coefficients of these terms in the resulting equation, by a least squares regression method.

The generalized form of the equation used (for a 5-variable problem) is shown in Figure 21. By inspection, the equation is capable of producing multiple order polynomial and triple cross product terms with non-integer exponents. The exponents and coefficients of the terms of the generalized equation are calculated in the fashion shown in the schematic, figure 22. The computerized method is started by selecting values for each of the exponents in the generalized regression equation in a random manner from within a range of exponents having both upper and lower bounds (e.g. $-2 \leq n \leq 2$). When specific exponents are applied, the equation formed is termed a specific regression equation. The next step in the computerized method is a standard least squares regression of the dependent variable in terms of the defined specific regression equation. A single figure-of-merit characterising the performance of the regression is identified by the user. Examples of types of figures-of-merit are: Maximum percent error, standard error of estimate, max delta, etc. The procedure selects a group of 50 (input variable) specific regression equations, each of which has randomly chosen exponents. The figure-of-merit is used within the CROP stochastic search module to first narrow the limits or bounds of potential exponents and then to stochastically select the next 50 sets of exponents for the generalized regression equation. The iteration is continued until the best set of exponents within the original range is selected to yield the best figure-of-merit resulting in a complete regression equation for the dependent variable of interest.

The CROP (Cluster Recognition Optimization Program) module is a P&WA developed program used previously on a wide variety of multi-variable optimization problems. It uses an accelerated stochastic search technique designed to select combinations of parameters that improve a prescribed figure-of-merit using multiple cluster recognition logic. In CROP, the parameters selected at random are the exponents; and, successive iterations result in a narrowing of the search bounds of the exponents in order to group together, or cluster, potential solutions to speed up convergence on the best set of exponents. This particular routine is capable of recognizing multiple sets of exponents (i.e., multiple clusters) that are valid.

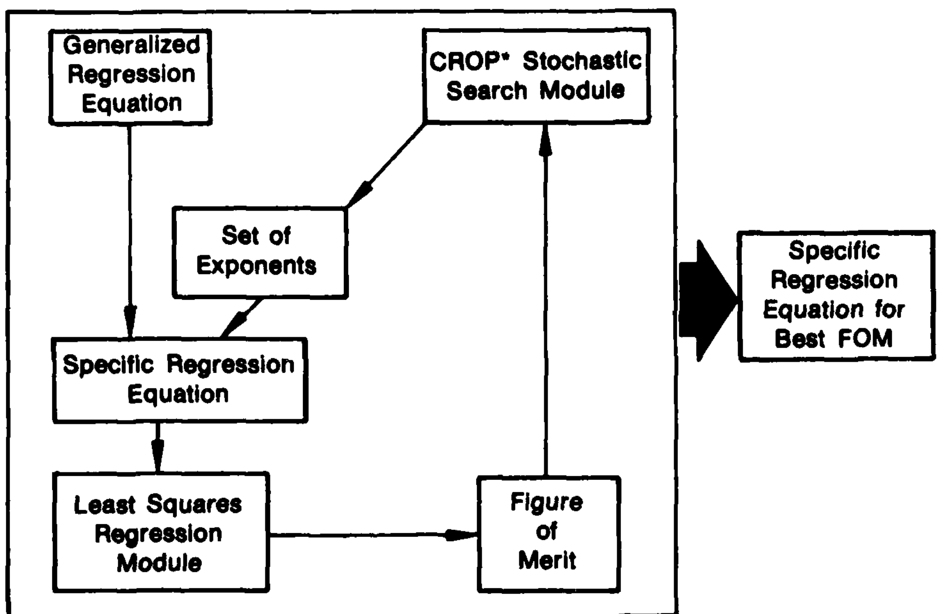
This method was applied to the Phase II data only. A summary of the analysis results are presented in tables 7 and 9 for a variety of equation forms and replication patterns for the five variable data set. The method is considered to be rather expensive considering that 2 million potential exponents are evaluated during a typical analysis. Therefore, its use was limited in this study to very selective cases and only to problems of fitting TOGW.

Generalized form of the regression equation for the Optimized Polynomial Exponent Method

$$
\begin{aligned}
f = a_0 &+ a_1 x^{M1} + a_2 x^{M2} + a_3 x^{M3} + a_4 x^{M4} + a_5 x^{M5} + a_6 x^{M6} \\
&+ a_7 x^{M7} + a_8 x^{M8} + a_9 x^{M9} + a_{10} x^{M10} \\
&+ a_{11} x^{M11}\, x^{M12}\, x^{M13} + a_{12} x^{M14}\, x^{M15}\, x^{M16} \\
&+ a_{13} x^{M17}\, x^{M18}\, x^{M19} + a_{14} x^{M20}\, x^{M21}\, x^{M22} \\
&+ a_{15} x^{M23}\, x^{M24}\, x^{M25} + a_{16} x^{M26}\, x^{M27}\, x^{M28} \\
&+ a_{17} x^{M24}\, x^{M30}\, x^{M31} + a_{18} x^{M32}\, x^{M33}\, x^{M34} \\
&+ a_{19} x^{M35}\, x^{M36}\, x^{M37} + a_{20} x^{M38}\, x^{M39}\, x^{M40}
\end{aligned}
$$

FD 146450

Figure 21. Generalized Form of the Regression Equation for the Optimized Polynomial Exponent Method



*Cluster Recognition Optimization Program (CROP)

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Figure 22. Cluster Recognition Optimization Program (CROP)

Table 7. Effect of Optimizing Exponents upon TOGW, Full Replication.

	Fit Deck	Optimized Polynomial Exponent Deck		
	Fix Single Term Exponents; Fix Double Cross-Product Exponents	Fix Single Term Exponents; Vary Double Cross-Product Exponents	Vary Single Term Exponents; Vary Double Cross-Product Exponents	Fix Single Term Exponents; Vary Triple Cross-Product Exponents
Max % Error	7.03	5.87	5.80	6.26
Average Delta	1265	1334	1579	1366
SEE	2345	2400	2799	2436
Average, %	2.00	2.06	2.50	2.13
PEE	3.52	3.48	4.61	3.51
Derivative Exponent, N	−1	−1	−1	−1

Table 8. Effect of Optimizing Exponents upon TOGW, Full vs Half Replication Comparison 5 Variable TOGW Fit. Fit Single Term Exponents; Vary Triple Cross-Product Exponents

Replication	Full	Augmented Half	
No. of Points Fit	43	27+1	27+1
Total Points Checked	43	27+1	43
Max % Error	6.26	4.55	9.54
Average Delta	1366	1353	1655
SEE	2436	3165	2760
Average, %	2.13	2.17	2.35
PEE	3.51	4.76	4.91
Derivative Exponent, N	−1	−1	−1

Table 7 is divided into two sections. Results for the best solution obtained using Transformations and Role-Reversal methodologies in a standard least squares regression fit of a second order polynomial form, are listed under the "fit" deck heading. For the three examples of Optimized Polynomial Exponent method shown, the figure-of-merit selected was maximum percent error. In each of these cases the maximum percent error was reduced when compared with the base line case, but increases in other statistics are apparent. As can be seen, the optimized polynomial method only reduced the max % error from 7% to about 6%, and produced no improvement in the SEE or average percent error.

SECTION V
PRESENTATION OF REGRESSION RESULTS

A. INTRODUCTION

The objectives of the Regression Simulation of Turbine Engine Performance (RSTEP) Task IV study include investigating the number of variables (5 through 10) and the number of data points required to provide sufficient confidence in the regression statistics accuracy. In each of the surface fits studied, a consistent group of statistics describing the regression were compared. Since most of these statistics are common to regression analysis, familiarity with their definitions is assumed in this report. Two statistics not well defined are average percent error and percent error of estimate (PEE). Average percent error is defined in this report to be the average of the absolute values of percent error. The PEE statistic is analogous to the standard error of estimate and is defined as the deviation of the percent error about the average percent error.

In addition to examining the statistics of the regressed data statistics of additional data termed "check points," were also examined for each surface fit. Check points are defined as data points, excluded from the regression data set, that are available for inspection. One source of these check points are data points left over when half (or quarter) replication of a variable is studied, but full (or half) replication data are available. A progressively larger source of check points is also available for increasing numbers of variable cases where points not normally calculated for a given number of variables to be regressed are at hand because the study includes a buildup in the number of variables regressed. This data is termed check data because values of independent variables for each check point are substituted into the regression equation to determine the value of the dependent variable for each check point. The value of the calculated dependent variable can then be compared or checked with the appropriate check data. Statistics for the combined regressed and check data can be calculated for comparisons. Examination of both regressed and check data has proved to be the only way to properly assess the surface fit accuracy.

The results present Phase II data only. The presentation is divided by parameters. The parameters investigated were: take-off gross weight (TOGW), take-off distance, combat acceleration time, combat g-load, and landing velocity. For each parameter the presentation is further broken down into five through ten variables for the range of replications studied. In general, the data presented represents the best results after application of Transformation and Role Reversal methodologies. For each surface fit, a table of characteristic statistics is presented; and, for TOGW, plots of the error distribution are presented. Each table, in general, includes the statistics for the regressed data and the cumulative statistics for regressed and check data (where available). The error distribution plots also present both regressed and check data. The shaded error distribution represents the regressed data results, while the cumulative results are presented in outline.

B. TOGW REGRESSION RESULTS

Of the five parameters studied, TOGW proved to be the most difficult to obtain good regression accuracy. The results are presented in Tables 9 through 20, and Figures 23 through 34.

Discussion of TOGW Regression Accuracy

Table 21 presents replication patterns studied for each of the numbers of variables considered.In general, results from the study show that for the five, six, seven, eight and nine independent variables, half replication is sufficient to accurately predict a regression surface. For the ten variable level, only the quarter replication pattern was studied, but the regression surfaces accuracy and error distribution indicate that quarter replication is acceptable for ten variables.

Table 9. Takeoff Gross Weight — 5 Variable Regression, Full Replication

No. of Points Fit	43
Total Points Checked	43
Max % Error	7.03
Average Delta	1265
SEE	2345
Average, %	2.00
PEE	3.52
R^2	0.9932
Derivative Exponent, N	−1

Table 10. Takeoff Gross Weight — 5 Variable Regression, Half Replication

No. of Points Fit	27	27	(27 + 1)
Total Points Checked	27	43	43
Max % Error	6.75	13.77	6.86
Average Delta	731	1456	1448
SEE	2022	2363	2609
Average, %	1.27	2.37	2.34
PEE	3.84	4.89	4.06
R^2	0.9958	—	—
Derivative Exponent, N	−1	—	—

Table 11. Takeoff Gross Weight — 6 Variable Regression, Full Replication

No. of Points Fit	77	77
Total Points Checked	77	87
Max % Error	8.79	11.26
Average Delta	1400	1524
SEE	2444	2540
Average, %	2.26	2.53
PEE	3.71	4.13
R^2	0.9914	—
Derivative Exponent, N	−1	—

Table 12. Takeoff Gross Weight — 6 Variable Regression, Half Replication

No. of Points Fit	45	45
Total Points Checked	45	87
Max % Error	8.55	9.90
Average Delta	1104	1463
SEE	2471	2647
Average, %	1.87	2.41
PEE	4.22	4.02
R^2	0.9926	—
Derivative Exponent, N	−1	—

Table 13. Takeoff Gross Weight — 7 Variable Regression, Full Replication

No. of Points Fit	143	143
Total Points Checked	143	165
Max % Error	8.51	8.83
Average Delta	1516	1622
SEE	2361	2448
Average, %	2.45	2.66
PEE	3.59	3.84
R^2	0.9911	—
Derivative Exponent, N	−1	—

Table 14. Takeoff Gross Weight — 7 Variable Regression, Half Replication

No. of Points Fit	79	79
Total Points Checked	79	165
Max % Error	8.42	9.36
Average Delta	1477	1585
SEE	2647	2451
Average, %	2.40	2.57
PEE	4.11	3.72
R^2	0.9908	—
Derivative Exponent, N	−1	—

Table 15. Takeoff Gross Weight — 8 Variable Regression, Full Replication

No. of Points Fit	273	273
Total Points Checked	273	309
Max % Error	13.14	13.86
Average Delta	1915	2027
SEE	2813	2925
Average, %	3.13	3.33
PEE	4.33	4.58
R^2	0.9861	—
Derivative Exponent, N	−1	—

Table 16. Takeoff Gross Weight — 8 Variable Regression, Half Replication

No. of Points Fit	145	145	145
Total Points Checked	145	273	309
Max % Error	12.50	12.50	12.90
Average Delta	1946	1929	2037
SEE	3154	2829	2932
Average, %	3.18	3.18	3.37
PEE	4.85	4.40	4.63
R^2	0.9848	—	—
Derivative Exponent, N	−1	—	—

Table 17. Takeoff Gross Weight — 8 Variable Regression, Quarter Replication

No. of Points Fit	81	81	81
Total Points Checked	81	273	309
Max % Error	6.74	94.42	94.42
Average Delta	9.69	9472.61	8642.56
SEE	1936	16619.60	15492.00
Average, %	1.58	17.23	15.68
PEE	3.04	33.86	31.54
R^2	0.9959	—	—
Derivative Exponent, N	0	—	—

Table 18. Takeoff Gross Weight — 9 Variable Regression, Half Replication

No. of Points Fit	275	275	275
Total Points Checked	275	403	455
Max % Error	17.79	17.79	17.79
Average Delta	2122	2065	2168
SEE	3196	2993	3076
Average, %	3.47	3.38	3.57
PEE	4.98	4.65	4.86
R^2	0.9820	—	—
Derivative Exponent, N	−1	—	—

Table 19. Takeoff Gross Weight — 9 Variable Regression, Quarter Replication

No. of Points Fit	147	147	147
Total Points Checked	147	403	455
Max % Error	14.07	35.13	35.13
Average Delta	1927	4062	3952
SEE	3358	6529	6266
Average, %	3.23	6.53	6.37
PEE	5.39	9.55	9.24
R^2	0.9827	—	—
Derivative Exponent, N	−1	—	—

Table 20. Takeoff Gross Weight — 10 Variable Regression, Quarter Replication

No. of Points Fit	277	277	277
Total Points Checked	277	533	603
Max % Error	17.13	17.13	17.13
Average Delta	1899	2141	2196
SEE	2965	3105	3117
Average, %	3.15	3.57	3.67
PEE	4.74	4.96	5.02
R^2	0.9844	—	—
Derivative Exponent, N	−1	—	—

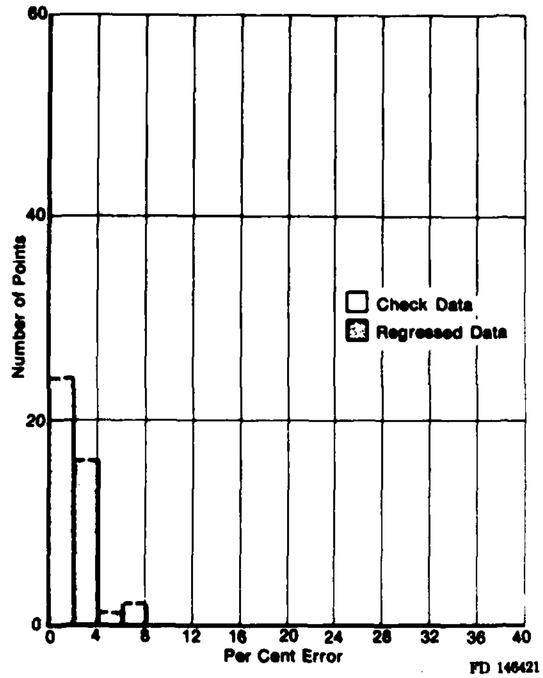

Figure 23. TOGW Error Distribution — Log Transformation 5 Variables, Full Replication

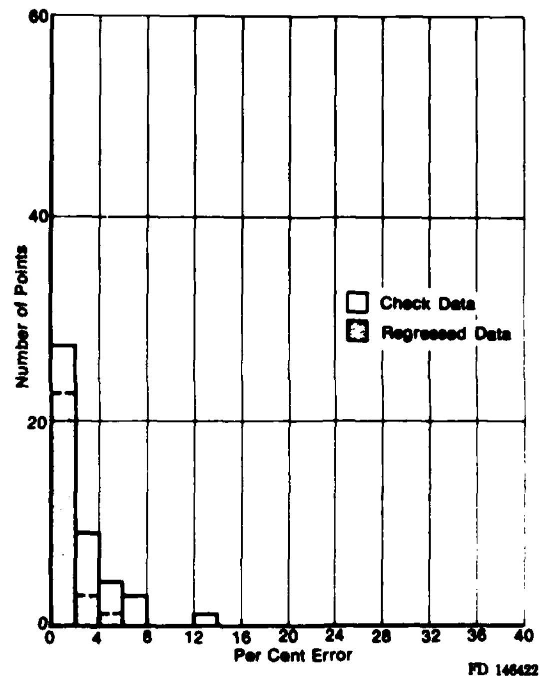

Figure 24. TOGW Error Distribution — Log Transformation 5 Variables, Half Replication

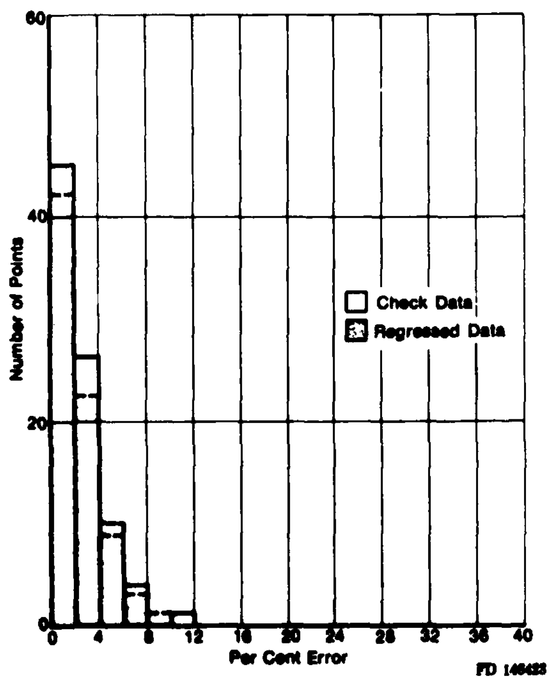

Figure 25. TOGW Error Distribution — Log Transformation 6 Variables, Full Replication

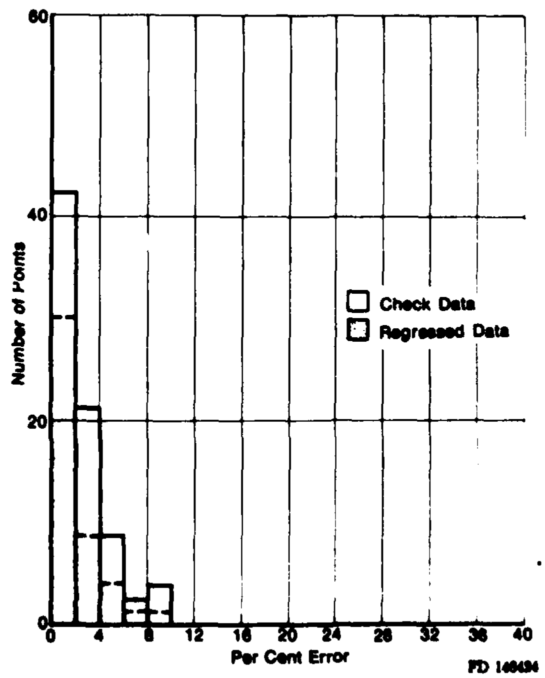

Figure 26. TOGW Error Distribution — Log Transformation 6 Variables, Half Replication

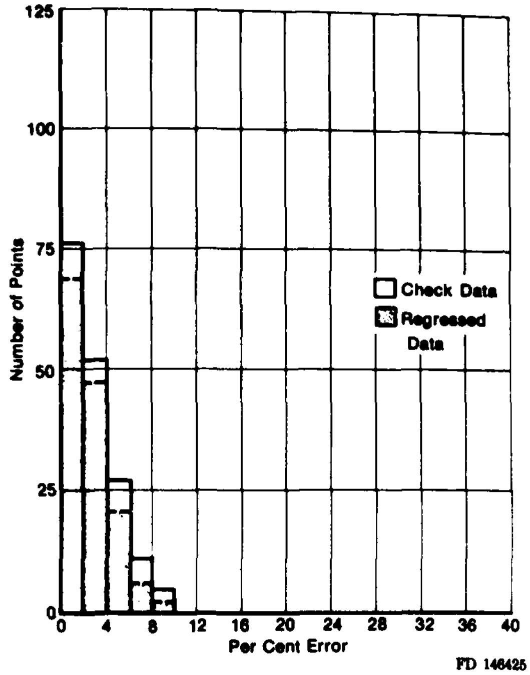

Figure 27. TOGW Error Distribution — Log Transformation 7 Variables, Full Replication

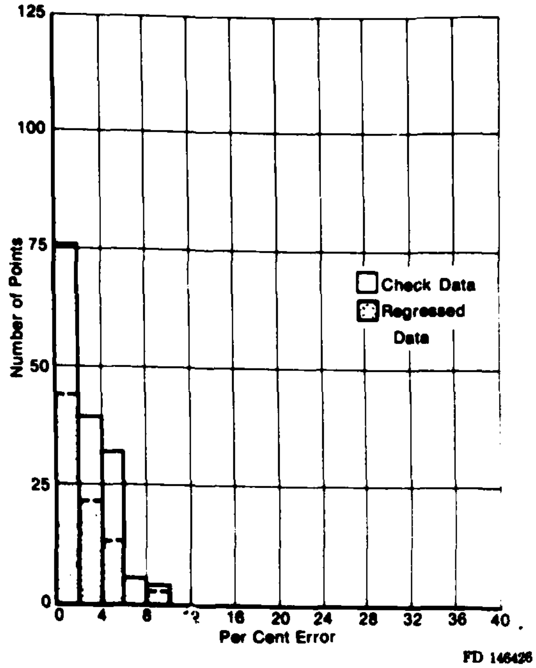

Figure 28. TOGW Error Distribution — Log Transformation 7 Variables, Half Replication

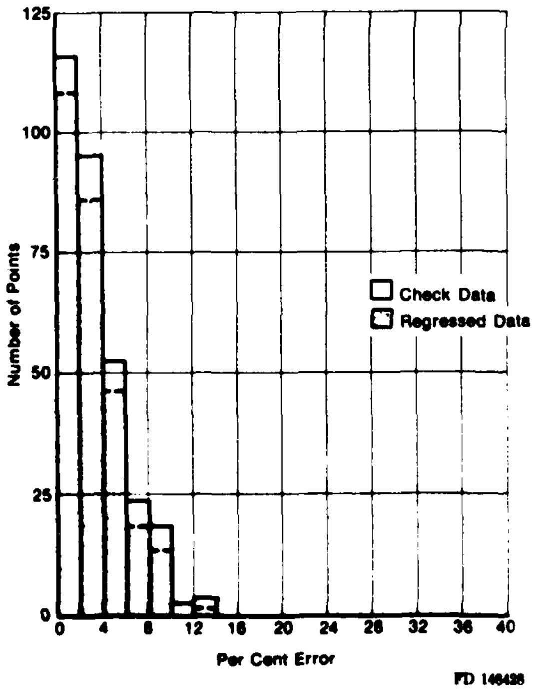

Figure 30. TOGW Error Distribution — Log Transformation 8 Variables, Half Replication

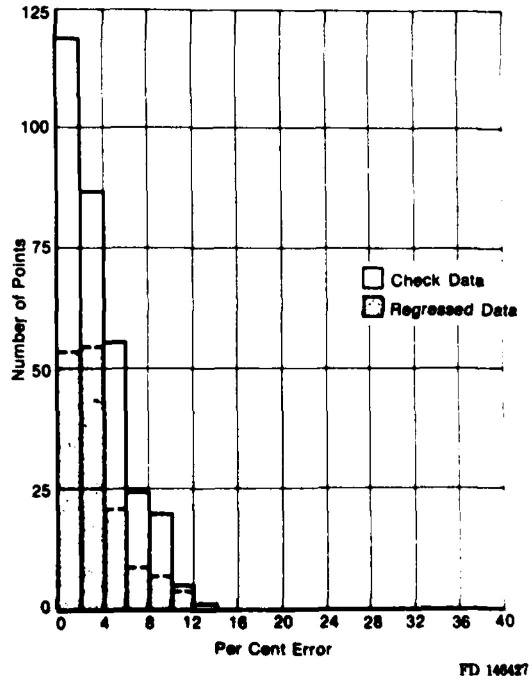

Figure 29. TOGW Error Distribution — Log Transformation 8 Variables, Full Replication

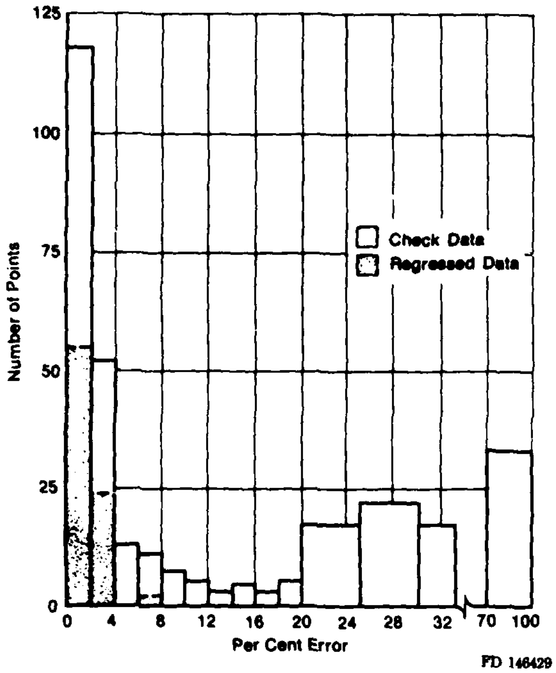

Figure 31. TOGW Error Distribution — Log Transformation 8 Variables, Quarter Replication

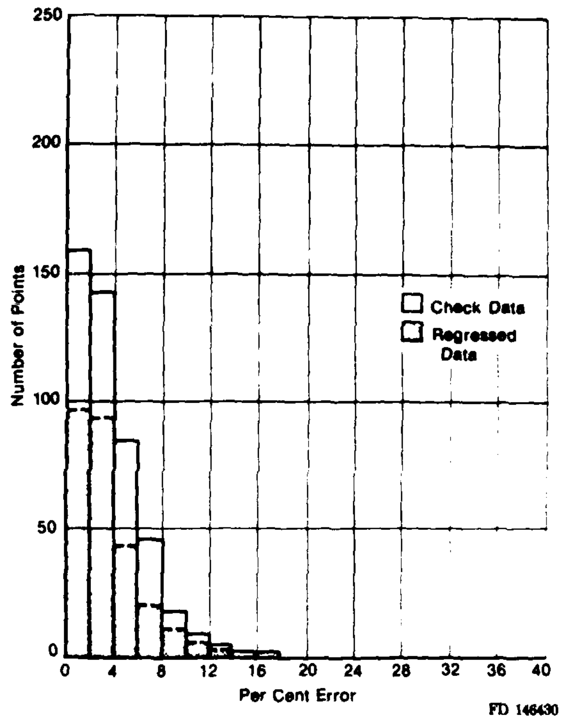

Figure 32. TOGW Error Distribution — Log Transformation 9 Variables, Half Replication

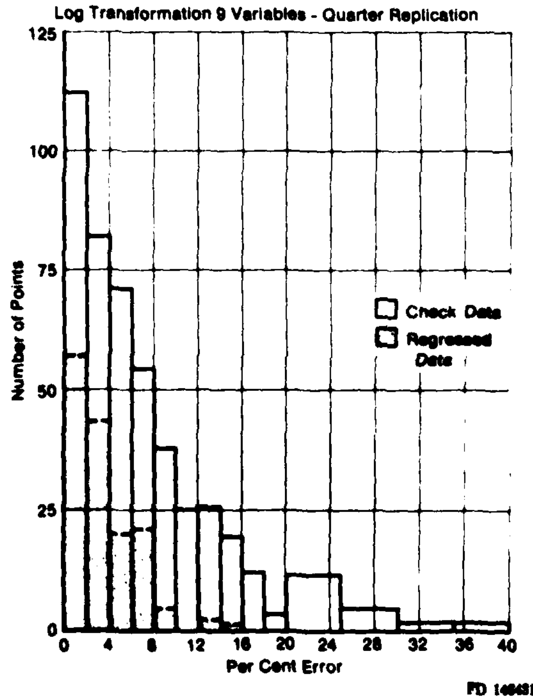

Figure 33. TOGW Error Distribution — Log Transformation 9 Variables, Quarter Replication

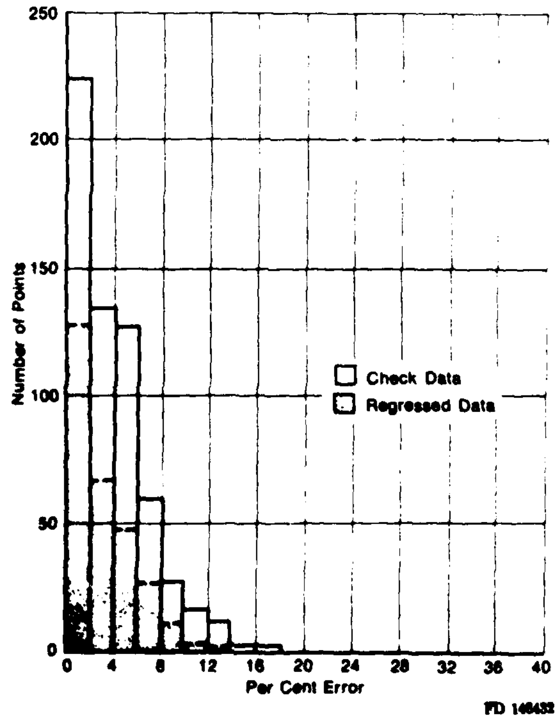

Figure 34. TOGW Error Distribution — Log Transformation 10 Variables, Quarter Replication

Table 21. TOGW Replication Patterns Studied

Number of Variables Regressed	*5*	*6*	*7*	*8*	*9*	*10*
Full Replication	X	X	X	X		
Half Replication	X	X	X	X	X	
Quarter Replication				X	X	X

Specifically for the TOGW 5-variable case, statistics for the half replication regression show an improvement over the full replication if only the regressed data is considered. The accuracy of the surface fit is comparable to the full replication case for all statistics except maximum percent error, which increased from 6.8% to 13.8%. Addition of the single check point that yielded the 14% error into the regression data set resulted in a dramatic reduction in the maximum percent error. Comparison of this half replication result, including assessing check points, with the full replication results shows that the surface fit accuracy is very similar.

Results for the six, seven, and eight variable comparison of full vs half replication show that half replication is well behaved. In these cases, half replication of the regressed data results in regression statistics very similar in level to those obtained for five variables. Note from the error distribution plots that the majority of errors are low, as indicated by the average error less than 2.5%.

Regression of eight variables was the first opportunity to examine quarter replication. Examination of the full and half replication regression statistics for both regressed and check data shows comparable accuracy.

The value of addressing check point data is apparent for the quarter replication of eight variables. The statistics of the regressed data shows considerable improvement over the full and half replication results. But, the error distribution chart shows how non-representative the surface fit is of the entire actual surface, as described by all available data. This indicates that quarter replication of eight variables does not provide sufficient data to prevent confounding the influence of the variable interactions.

Nine-variable half replication results are similar to those obtained for the 8-variable half replication with the exception of maximum percent error which is higher. Inspection of the cumulative regressed and check data statistics shows that 9-variable quarter replication pattern does not include sufficient data points to describe the surface. The quarter replication error distribution is improved relative to the comparable 8-variable data, but quarter replication of nine variables is not sufficiently accurate.

Ten variable quarter replication results show a slight improvement in statistical accuracy when compared with the 9-variable half replication regression results, although the maximum percent error is still on the order of 17%. The error distribution chart shows the regressed data to be well behaved, which indicates that quarter replication of ten variables provides sufficient data to define the surface. Results for 8- and 9-variable half replication and the 10-variable quarter replication are considered to be statistically similar.

A summary of results for the minimum replications of each variable is presented in figure 35. The chart shows that two levels of accuracy can be identified as a function of the number of variables considered. At the 5-, 6-, and 7-variable levels the level of accuracy is on the order of 8% maximum percent error with an excellent 2 to 2.5% average error. For the 8-, 9- and 10-variable level where variables of less influence, such as OPR, A8 and AR were considered, the maximum errors increase to approximately 17% while the average percent error rose only slightly to approximately 3%. Closer examination of the high error points show that only three data points

(which represent extreme combinations of independent variables) result in the high maximum percent errors. If these same three data points are eliminated from consideration for the 9- and 10-variable cases, the maximum percent errors drop dramatically to the 8-variable level. Note then that there are two distinct levels of accuracy, one at 8% maximum error and one at 13% maximum error. One possible conclusion is that the first seven variables selected sufficiently for study are the strongest aircraft/propulsion system drivers and that increasing numbers of variables introduces "noise" into the analysis.

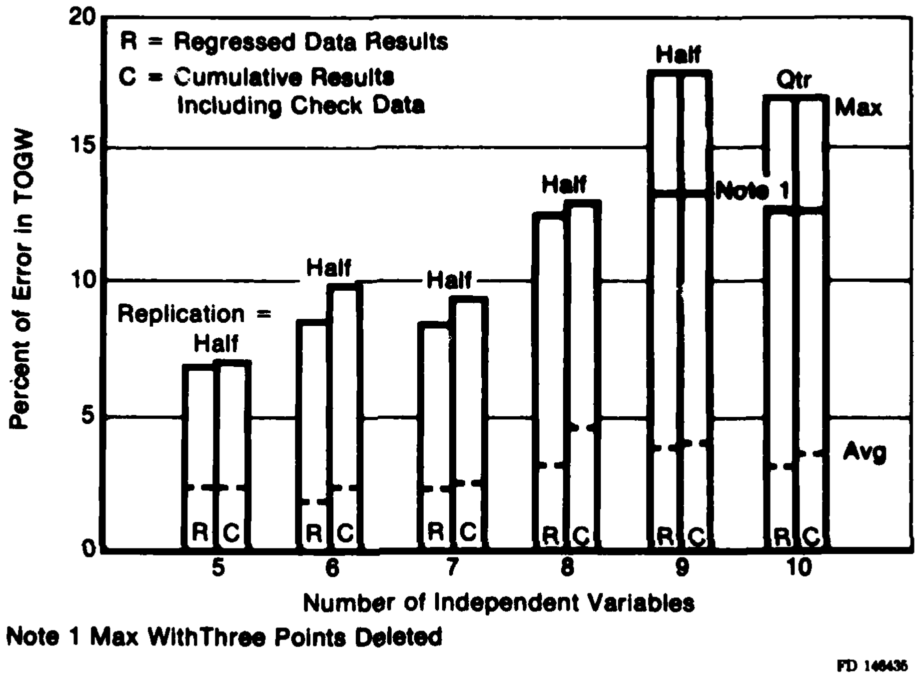

Figure 35. TOGW Check Data Comparison Summary

The lesser significance of the variables A8, OPR, and AR is indicated by two methods of determining the conditioning of the normal equation matrix in the least squares procedure. Rosanoff and Ginsburg (Ref. 5) have shown that the condition of matrix can be determined by comparing the ratio of extreme eigenvalues of a matrix. Further, the logarithm to the base ten of this ratio is an estimate of the maximum number of significant figures lost in the inversion or solution of the normal equations. Examination of the RSTEP Task IV data shows that the 8-, 9-, and 10-variable cases definitely lose at least one more significant digit in the calculation process than the 5- and 6-variable cases.

Another measure of matrix conditioning is given by Wilkinson (Ref. 6). In this method each terms in the normal equation is divided by the square root of the sum of the squares of its coefficients and then the determinant of the normalized coefficient matrix is evaluated. The smaller the magnitude of the normalized determinant in comparison with ± 1, the more ill-conditioned the set is. Using this criteria, results for eight, nine, and ten variables are an order of magnitude worse than the 7-variable level.

A regression analysis of OPR rather than A8 as the eighth variable in an 8-variable analysis of TOGW shows similar regression statistics and conditioning of the matrix. This would indicate that the first seven variables selected for this study are the primary drivers upon TOGW and that variables such as A8, OPR, and AR (for the range of values studied) may have significantly less influence upon TOGW.

C. TAKEOFF DISTANCE RESULTS

Regression simulation of takeoff distance proved to be easy and to provide excellent regression statistics when transformations were used. Results are presented in Tables 22 through 29.

Table 22. Takeoff Distance — 5 Variable Regression, Full Replication

No. of Points Fit	43
Total Points Checked	43
Max % Error	1.01
Average Delta	3.63
SEE	7.85
Average, %	0.16
PEE	0.33
R^2	0.9999
Derivative Exponent, N	−2

Table 23. Takeoff Distance — 6 Variable Regression, Full Replication

No. of Points Fit	77
Total Points Checked	77
Max % Error	0.90
Average Delta	2.75
SEE	5.44
Average, %	0.12
PEE	0.23
R^2	0.9999
Derivative Exponent, N	−2

Table 24. Takeoff Distance — 7 Variable Regression, Full Replication

No. of Points Fit	143
Total Points Checked	143
Max % Error	0.79
Average Delta	14.30
SEE	20.37
Average, %	0.43
PEE	0.53
R^2	0.9999
Derivative Exponent, N	−1

Table 25. Takeoff Distance — 8 Variable Regression, Full Replication

No. of Points Fit	273	273
Total Points Checked	273	309
Max % Error	0.92	1.48
Average Delta	14.78	13.92
SEE	20.01	18.92
Average, %	0.44	0.43
PEE	0.51	0.51
R^2	0.9999	—
Derivative Exponent, N	−1	—

Table 26. Takeoff Distance — 8 Variable Regression, Half Replication

No. of Points Fit	145	145	145
Total Points Checked	145	273	309
Max % Error	0.90	0.94	1.38
Average Delta	14.17	14.76	13.85
SEE	21.44	19.98	18.87
Average, %	0.42	0.44	0.42
PEE	0.55	0.51	0.51
R^2	0.9999	—	—
Derivative Exponent, N	−1	—	—

Table 27. Takeoff Distance — 9 Variable Regression, Half Replication

No. of Points Fit	275	275	275
Total Points Checked	275	403	455
Max % Error	1.07	1.07	1.38
Average Delta	14.74	14.97	14.11
SEE	20.76	20.11	19.07
Average, %	0.44	0.44	0.43
PEE	0.53	0.51	0.51
R^2	0.9999	—	—
Derivative Exponent, N	−1	—	—

Table 28. Takeoff Distance — 9 Variable Regression, Quarter Replication

No. of Points Fit	147	147	147
Total Points Checked	147	403	455
Max % Error	1.07	30.46	30.46
Average Delta	13.73	323.75	287.68
SEE	22.24	627.70	585.54
Average, %	0.40	9.23	8.22
PEE	0.57	15.01	14.01
R^2	0.9999	—	—
Derivative Exponent, N	−1	—	—

Table 29. Takeoff Distance — 10 Variable Regression, Quarter Replication

No. of Points Fit	277	277	277
Total Points Checked	277	533	603
Max % Error	1.02	1.11	1.23
Average Delta	14.66	15.12	14.05
SEE	21.06	20.09	18.95
Average, %	0.43	0.44	0.42
PEE	0.54	0.51	0.50
R^2	0.9999	—	—
Derivative Exponent, N	−1	—	—

Discussion of Takeoff Distance Regression Accuracy

Table 30 presents replication patterns studied for each of the number of variables considered.

Table 30. Takeoff Distance Replication Patterns Studied

Number of Variables Regressed	5	6	7	8	9	10
Full Replication	X	X	X	X		
Half Replication				X	X	
Quarter Replication					X	X

The regression statistics show maximum percent error for regressed values of takeoff distance of approximately 1% and average percent errors of 0.4%. For each case, transformation methodology was used to reduce the errors from a 12 to 30% range to a 1% level. Results for takeoff distances prediction on a per variable replication basis appear to be similar to results obtained for TOGW (see figure 36). Thus, a half replication pattern should be sufficient to accurately represent takeoff distance surfaces for 5- through 9-variables, and quarter replication for ten variables. Note that for the 9-variable quarter replication case, examination of the check point results shows that the quarter replication pattern provides too few points. This is the same result seen in the TOGW regression study. Examination of check points for the 10-variable quarter replication shows that 277 data points are sufficient to regress the takeoff distance surface for 10-variables.

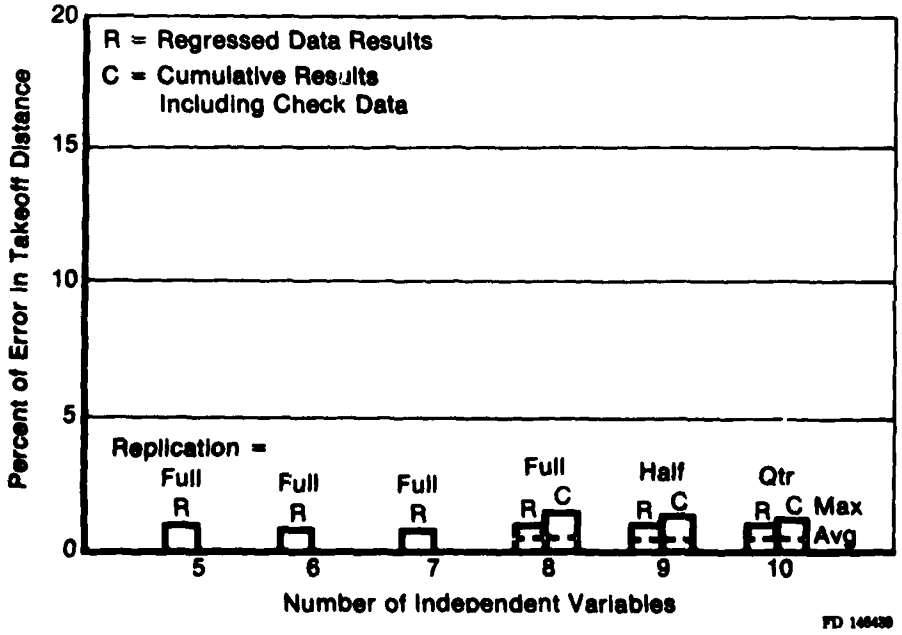

Figure 36. Takeoff Distance Results Summary

D. COMBAT ACCELERATION TIME RESULTS

Regression simulation of combat accel time required transformation methods to obtain surface fit accuracies that were good but not excellent. Results are presented in Tables 31 through 36.

Table 31. Combat Acceleration Time — 5 Variable Regression, Full Replication

No. of Points Fit	43
Total Points Checked	43
Max % Error	3.51
Average Delta	0.57
SEE	1.59
Average, %	0.65
PEE	1.39
R^2	0.9998
Derivative Exponent, N	−2

Table 32. Combat Acceleration Time — 6 Variable Regression, Full Replication

No. of Points Fit	77
Total Points Checked	77
Max % Error	4.61
Average Delta	0.62
SEE	1.63
Average, %	0.67
PEE	1.38
R^2	0.9997
Derivative Exponent, N	−2

Table 33. Combat Acceleration Time — 7 Variable Regression, Full Replication

No. of Points Fit	143
Total Points Checked	143
Max % Error	4.57
Average Delta	0.60
SEE	1.31
Average, %	0.70
PEE	1.21
R^2	0.9997
Derivative Exponent, N	−2

Table 34. Combat Acceleration Time — 8 Variable Regression, Full Replication

No. of Points Fit	273	273
Total Points Checked	273	309
Max % Error	9.67	9.67
Average Delta	1.23	1.16
SEE	2.41	2.25
Average, %	1.37	1.36
PEE	2.07	2.00
R^2	0.9993	—
Derivative Exponent, N	−2	—

Table 35. Combat Acceleration Time — 9 Variable Regression, Half Replication

No. of Points Fit	275	275	275
Total Points Checked	275	403	455
Max % Error	7.97	10.03	10.03
Average Delta	1.14	1.20	1.13
SEE	2.27	2.34	2.22
Average, %	1.27	1.33	1.29
PEE	2.01	2.03	1.97
R^2	0.9993	—	—
Derivative Exponent, N	−2	—	—

Table 36. Combat Acceleration Time — 10 Variable Regression, Quarter Replication

No. of Points Fit	277	277	277
Total Points Checked	277	533	603
Max % Error	7.71	9.90	9.90
Average Delta	1.18	1.29	1.21
SEE	2.49	2.49	2.35
Average, %	1.27	1.41	1.37
PEE	2.06	2.16	2.08
R^2	0.9994	—	—
Derivative Exponent, N	−2	—	—

Discussion of Combat Accel Time Regression Accuracy

Table 37 presents replication patterns studied for each of the numbers of variables considered.

Table 37. Combat Acceleration Time Replication Patterns Studied

Number of Variables Regressed	*5*	*6*	*7*	*8*	*9*	*10*
Full Replication	X	X	X	X		
Half Replication					X	
Quarter Replication						X

Figure 37 shows that there are two levels of accuracy in predicting combat accel time and that these levels are a function of the numbers of variables considered. For the full replication regression of 5-, 6-, and 7-variables, the accuracy is excellent with the maximum percent error hovers around 4.5%, and an average percent error of 0.7%. For replication patterns studied for 8-, 9-, and 10-variables the maximum percent error increases to somewhat less than 10% and an average error of 1.3%. Although these errors are somewhat higher, the correlation coefficient would indicate that 99.93% of the variation of the data is being accounted for with the regression equations developed.

Results of the study indicate that this variable is similar to TOGW and TO distance in terms of the numbers and points required as input to the regression in order to sufficiently describe the surface.

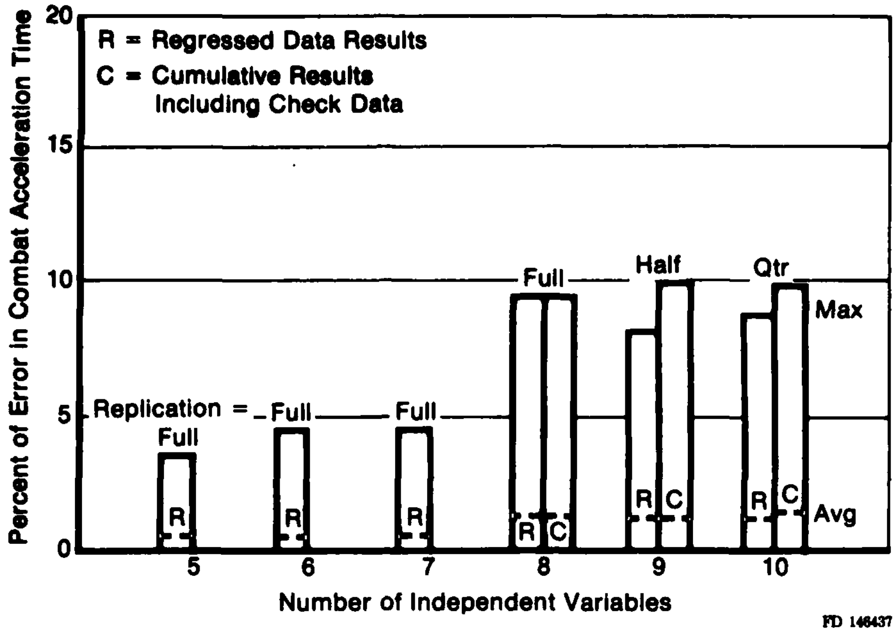

Figure 37. Combat Acceleration Time Results Summary

E. COMBAT G-LOAD RESULTS

Regression simulation of combat g-load proved to be straightforward, and excellent regression statistics were obtained. Results are presented below in Tables 38 through 44.

Table 38. Combat g Load — 5 Variable Regression, Full Replication

No. of Points Fit	43
Total Points Checked	43
Max % Error	0.66
Average Delta	0.00
SEE	0.01
Average, %	0.17
PEE	0.31
R^2	0.9998
Derivative Exponent, N	0

Table 39. Combat g Load — 6 Variable Regression, Full Replication

No. of Points Fit	77
Total Points Checked	77
Max % Error	0.56
Average Delta	0.00
SEE	0.01
Average, %	0.15
PEE	0.24
R^2	0.9999
Derivative Exponent, N	0

Table 40. Combat g Load — 7 Variable Regression, Full Replication

No. of Points Fit	143
Total Points Checked	143
Max % Error	1.32
Average Delta	0.01
SEE	0.01
Average, %	0.22
PEE	0.34
R^2	0.9997
Derivative Exponent, N	0

Table 41. Combat g Load — 8 Variable Regression, Full Replication

No. of Points Fit	273	273
Total Points Checked	273	309
Max % Error	1.37	1.37
Average Delta	0.01	0.01
SEE	0.01	0.01
Average, %	0.29	0.31
PEE	0.41	0.42
R^2	0.9996	—
Derivative Exponent, N	0	—

Table 42. Combat g Load — 8 Variable Regression, Half Replication

No. of Points Fit	145	145	145
Total Points Checked	145	273	309
Max % Error	1.34	1.34	1.34
Average Delta	0.01	0.01	0.01
SEE	0.01	0.01	0.01
Average, %	0.29	0.30	0.31
PEE	0.45	0.41	0.43
R^2	0.9995	—	—
Derivative Exponent, N	0	—	—

Table 43. Combat g Load — 9 Variable Regression, Half Replication

No. of Points Fit	275	275	275
Total Points Checked	275	403	455
Max % Error	1.58	1.58	1.58
Average Delta	0.01	0.01	0.01
SEE	0.01	0.01	0.01
Average, %	0.33	0.32	0.34
PEE	0.48	0.45	0.47
R^2	0.9994	—	—
Derivative Exponent, N	0	—	—

Table 44. Combat g Load — 10 Variable Regression, Quarter Replication

No. of Points Fit	277	277	277
Total Points Checked	277	533	603
Max % Error	3.82	3.82	4.13
Average Delta	0.02	0.03	0.03
SEE	0.03	0.03	0.04
Average, %	0.98	1.08	1.17
PEE	1.40	1.43	1.52
R^2	0.9970	—	—
Derivative Exponent, N	0	—	—

Discussion of Combat g-Load Regression Accuracy

Table 45 presents replication patterns studied for each of the numbers of variables considered.

Table 45. Combat g-Loading Replication Patterns Studied

Number of Variables Regressed	*5*	*6*	*7*	*8*	*9*	*10*
Full Replication	X	X	X	X		
Half Replication				X	X	
Quarter Replication						X

A summary of results is presented in figure 38. Regression statistics presented show that for surface fitting, and 5- through 9-variables, maximum percent errors less than 1.5% were obtained and that at the 10-variable level a maximum percent error less than 4% was obtained. In general, the average errors were 0.3%, except the 10-variable case where approximately 1% average errors were obtained.

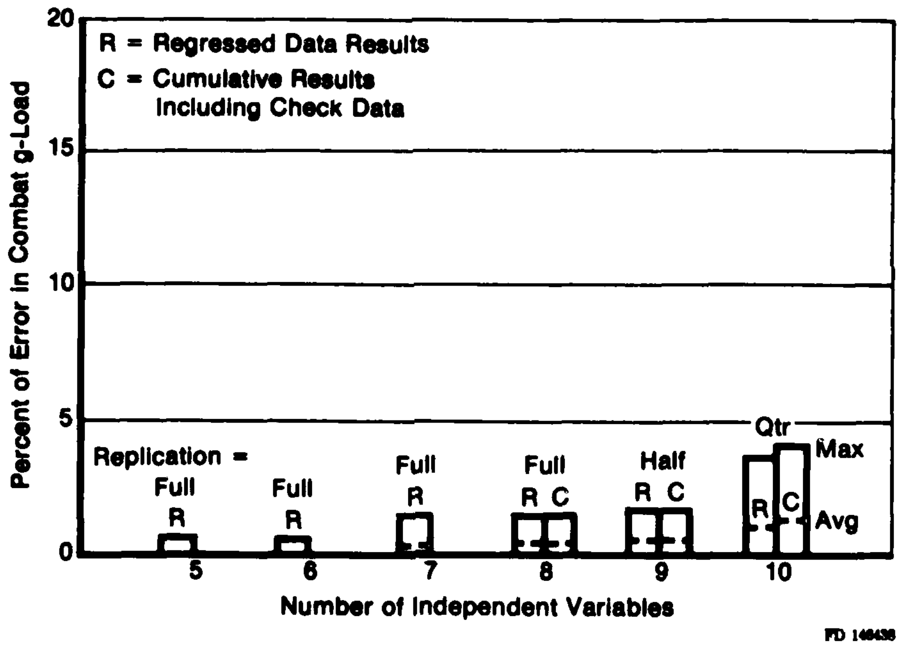

Figure 38. Combat g-Load Results Summary

F. LANDING VELOCITY RESULTS

Regression simulation of landing velocity proved to be straightforward and excellent regression statistics were obtained. Results, in tabular form are presented in Tables 46 through 51.

Table 46. Landing Velocity — 5 Variable Regression, Half Replication

No. of Points Fit	27	27
Total Points Checked	27	43
Max % Error	0.31	0.38
Average Delta	0.10	0.12
SEE	0.30	0.23
Average, %	0.08	0.10
PEE	0.24	0.19
R^2	0.9999	—
Derivative Exponent, N	0	—

Table 47. Landing Velocity — 6 Variable Regression, Half Replication

No. of Points Fit	45	45	45
Total Points Checked	45	77	87
Max % Error	0.52	0.52	0.98
Average Delta	0.19	0.20	0.24
SEE	0.38	0.31	0.37
Average, %	0.15	0.16	0.19
PEE	0.30	0.24	0.30
R^2	0.9996	—	—
Derivative Exponent, N	0	—	—

Table 48. Landing Velocity — 7 Variable Regression, Half Replication

No. of Points Fit	79	79	79
Total Points Checked	79	143	165
Max % Error	0.76	0.97	1.25
Average Delta	0.34	0.31	0.33
SEE	0.58	0.46	0.48
Average, %	0.23	0.21	0.23
PEE	0.38	0.31	0.35
R^2	0.9998	—	—
Derivative Exponent, N	0	—	—

Table 49. Landing Velocity — 8 Variable Regression, Half Replication

No. of Points Fit	145	145	145
Total Points Checked	145	278	309
Max % Error	0.90	0.90	1.37
Average Delta	0.32	0.32	0.35
SEE	0.50	0.44	0.49
Average, %	0.21	0.21	0.24
PEE	0.33	0.29	0.35
R^2	0.9998	—	—
Derivative Exponent, N	0	—	—

Table 50. Landing Velocity — 9 Variable Regression, Half Replication

No. of Points Fit	275	275	275
Total Points Checked	275	403	455
Max % Error	1.49	1.49	1.49
Average Delta	0.39	0.39	0.40
SEE	0.56	0.53	0.54
Average, %	0.26	0.25	0.27
PEE	0.37	0.35	0.36
R^2	0.9998		—
Derivative Exponent, N	0	—	—

Table 51. Landing Velocity — 10 Variable Regression, Quarter Replication

No. of Points Fit	277	277	277
Total Points Checked	277	533	603
Max % Error	1.42	1.42	1.42
Average Delta	0.41	0.41	0.42
SEE	0.60	0.56	0.56
Average, %	0.26	0.27	0.27
PEE	0.39	0.36	0.37
R^2	0.9998	—	—
Derivative Exponent, N	0	—	—

Discussion of Landing Velocity Regression Accuracy

Table 52 presents replication patterns studied for each of the numbers of variables considered.

For each of the numbers of variables examined, excellent regression statistics were obtained for regressed values of landing velocity without transformations. Regression of half replication pattern of velocity as a function of 5-, 6-, 7-, and 8-variables resulted in maximum percent errors less than 1%. Results for 9- and 10-variable cases show only slightly higher maximum percent errors of 1.5%. Inspection of check data, shown graphically in figure 39, for each of these regression cases, shows similar maximum and average percent errors.

Thus, a half replication pattern is sufficient to accurately represent landing velocity surfaces for 5- through 9-variables. Quarter replication provides sufficient points to accurately represent 10 variables.

Table 52. Landing Velocity Replication Patterns Studied

Number of Variables Regressed	*5*	*6*	*7*	*8*	*9*	*10*
Full Replication						
Half Replication	X	X	X	X	X	
Quarter Replication						X

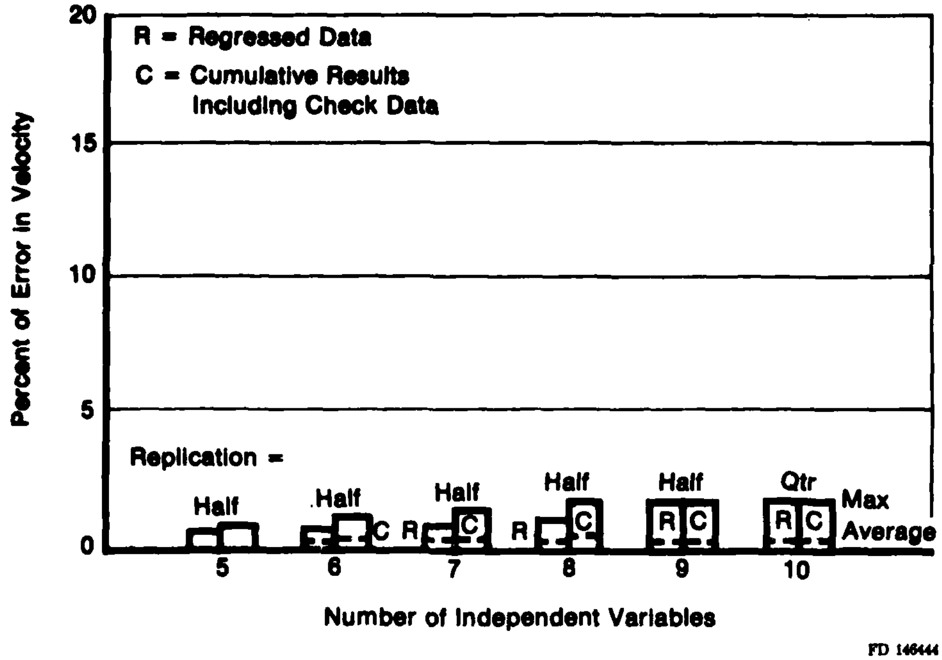

Figure 39. Landing Velocity Results Summary

SECTION VI
CONCLUSIONS

During the Regression Simulation of Turbine Engine Performance (RSTEP) Task IV study, the Central Composite Design (CCD) pattern was evaluated as an alternate to the Orthogonal Latin Square (OLS) design selector used in Turbine Engine Variable Cycle Selection Study (TEVCS), Airplane Responsive Engine Selection Study (ARES). The investigation included the systematic evaluation of the impact of the number of independent variables and the number of data points on regression accuracy. Four approaches to improve the accuracy of the regression equation form were also investigated. The conclusions drawn from the results of this study are presented below.

- The CCD design selector provides a flexible, accurate, and economical alternate to the OLS design selector. Data generation cost of the CCD design selector ranges from a 60% reduction (compared to the OLS cost) for a 5-variable problem to a 22% reduction for 9- and 10-variable problems.

- Satisfactory regression accuracy is obtained with half replication of the CCD pattern for 5- through 9-variable problems, and quarter replication for 10-variable problems.

- Transformation of the dependent variable is the single most powerful tool studied. A maximum error of 34% obtained by traditional regression of Take-Off Gross Weight (TOGW) was reduced to 12% by application of Transformation methodology.

- Role Reversal methodology provides a means to obtain further significant accuracy improvement by reducing the maximum TOGW error from 12% to 7%.

- Statistics based on data used in the regression are not a reliable indication of the regression surface accuracy. Check points provide a means of obtaining greater confidence in the accuracy level.

SECTION VII
RECOMMENDATIONS

Based on results of the Regression Simulation of Turbine Engine Performance (RSTEP) Task IV Program, three recommendations about future regression analysis of airframe/propulsion systems have been developed:

- Transformations and Role Reversal methodologies have proven to be very effective in improving surface fit accuracy and should be incorporated into future studies.
- The Central Composite Design (CCD) design selector provides a flexible, accurate, and economical alternative to the Orthogonal Latin Square (OLS) design selector. Therefore, the CCD pattern should be considered for future studies.
- Data points additional to those used in the regression should be generated and used to check the regression surface accuracy.
- A back-to-back accuracy comparison of other design selection patterns such as Latin Squares and D_N optimal should be investigated over a range of numbers of independent variables. The comparison should be made on the basis of regression statistics and constrained optimal surface prediction accuracy.

APPENDIX A
PHASE II DATA RSTEP TASK IV STUDY

The following computerized listing presents data generated by the Boeing Company under contract to P&WA. The listing includes 17 parameters consisting of data point numbers, independent variables, dependent variables, and a replication code.

The first column is the data point number used to identify individual data. The next five columns present dependent variables or fall-outs from the mission calculation. The seventh through sixteenth columns list the independent variables used as input to the Boeing BEAM calculation. The last column presents the replication code. This six-digit code is used to define points in the CCD pattern that are used with specific numbers and variables and breaks out how these points are used in replications.

Each digit in the code corresponds with a specific number of variables to be regressed. Digit one is for five variables, digit two is for six variables, etc... Each of these digits can have four possible values (0, 1, 2, or 3). Zero means that the data point is not used in any replication pattern of the specified number of variables considered. A 1 in the code means that the data point is used in full replication only. A 2 means that the data point is used in both full and half replication. A 3 in the code means the point is used in full, half, and quarter replication. Note that points used in half (or quarter) replication are always used in full replication, but that a point in full (or half) replication may not necessarily be included in a half (or quarter) replication pattern.

Example: 001230

This data point is not used in the five, six, or ten variable CCD patterns. The point is used in full, but not half or quarter replication of seven variables. The point is used in full and half replication of eight variables. The same data is used in full, half, and quarter replication of the ninth variable.

N	RANGE DASH(NM)	TO DIST (FT)	VEL (FT/SEC)	TIME (SEC)	G-LOAD	BPR	TR	T/W	W/S	GW (LBS)	T4 (DEGREES)	SWEEP (DEGREES)	AB	OPR	AR	ID
1.0	85.17	2042.0	125.30	48.02	2.384	1.00	1.07	1.00	100.0	60000.0	2400.0	35.0	-1.0	20.0	1.50	220000
2.0	5.60	2042.0	133.20	52.20	2.307	1.00	1.07	1.00	100.0	40000.0	2400.0	35.0	-1.0	20.0	1.50	200000
3.0	104.30	2804.0	119.80	86.44	2.016	1.00	1.07	0.70	100.0	60000.0	2400.0	35.0	-1.0	20.0	1.50	200000
4.0	131.10	2042.0	121.20	46.37	2.423	1.00	1.07	1.00	100.0	80000.0	2400.0	35.0	-1.0	20.0	1.50	200000
5.0	44.72	1684.0	130.40	34.10	2.649	1.00	1.07	1.30	100.0	60000.0	2400.0	35.0	-1.0	20.0	1.50	200000
6.0	53.48	1745.0	116.50	49.46	2.656	1.00	1.15	1.00	80.0	60000.0	2400.0	35.0	-1.0	20.0	1.50	200000
7.0	65.92	1736.0	114.40	49.82	2.675	1.00	1.07	1.00	80.0	60000.0	2400.0	35.0	-1.0	20.0	1.50	200000
8.0	81.31	2066.0	124.30	55.98	2.438	1.00	1.00	1.00	100.0	60000.0	2400.0	35.0	-1.0	20.0	1.50	200000
9.0	97.43	2370.0	135.50	47.34	2.150	1.00	1.07	1.00	120.0	60000.0	2400.0	35.0	-1.0	20.0	1.50	200000
10.0	148.90	3446.0	124.10	90.43	1.917	1.80	1.00	0.70	120.0	80000.0	2400.0	35.0	-1.0	20.0	1.50	222223
11.0	34.47	3446.0	138.30	111.60	1.813	1.80	1.00	0.70	120.0	40000.0	2400.0	35.0	-1.0	20.0	1.50	111111
12.0	104.60	2342.0	106.10	100.37	2.403	1.80	1.00	0.70	80.0	80000.0	2400.0	35.0	-1.0	20.0	1.50	111111
13.0	17.97	2342.0	116.10	131.87	2.277	1.80	1.00	0.70	80.0	40000.0	2400.0	35.0	-1.0	20.0	1.50	222323
14.0	-21.37	1494.0	124.80	40.75	3.015	1.80	1.00	1.30	80.0	40000.0	2400.0	35.0	-1.0	20.0	1.50	111111
15.0	63.95	1494.0	114.90	36.94	3.148	1.80	1.00	1.30	80.0	80000.0	2400.0	35.0	-1.0	20.0	1.50	222323
16.0	-24.97	1948.0	149.80	38.92	2.370	1.80	1.00	1.30	120.0	40000.0	2400.0	35.0	-1.0	20.0	1.50	222223
17.0	87.47	1948.0	135.80	35.55	2.471	1.80	1.00	1.30	120.0	80000.0	2400.0	35.0	-1.0	20.0	1.50	111111
18.0	75.08	2066.0	125.50	46.94	2.367	1.80	1.07	1.00	100.0	60000.0	2400.0	35.0	-1.0	20.0	1.50	200000
19.0	14.10	2351.0	118.10	98.14	2.161	1.80	1.15	0.70	80.0	40000.0	2400.0	35.0	-1.0	20.0	1.50	111111
20.0	117.70	2351.0	108.20	78.62	2.305	1.80	1.15	0.70	80.0	80000.0	2400.0	35.0	-1.0	20.0	1.50	222323
21.0	25.26	3444.0	141.10	89.96	1.721	1.80	1.15	0.70	120.0	40000.0	2400.0	35.0	-1.0	20.0	1.50	222223
22.0	132.20	3444.0	127.10	73.80	1.831	1.80	1.15	0.70	120.0	80000.0	2400.0	35.0	-1.0	20.0	1.50	111111
23.0	55.09	1947.0	140.60	31.29	2.366	1.80	1.15	1.30	120.0	80000.0	2400.0	35.0	-1.0	20.0	1.50	222223
24.0	-64.30	1947.0	154.50	33.82	2.269	1.80	1.15	1.30	120.0	40000.0	2400.0	35.0	-1.0	20.0	1.50	111111
25.0	47.86	1497.0	118.70	32.05	3.009	1.80	1.15	1.30	80.0	80000.0	2400.0	35.0	-1.0	20.0	1.50	111111
26.0	-49.96	1497.0	128.50	34.82	2.880	1.80	1.15	1.30	80.0	40000.0	2400.0	35.0	-1.0	20.0	1.50	222323
27.0	66.87	1897.0	139.70	33.49	2.406	0.20	1.15	1.30	120.0	80000.0	2400.0	35.0	-1.0	20.0	1.50	111111
28.0	-70.19	1897.0	153.30	36.90	2.304	0.20	1.15	1.30	120.0	40000.0	2400.0	35.0	-1.0	20.0	1.50	222333
29.0	47.02	1467.0	118.20	34.76	3.051	0.20	1.15	1.30	80.0	80000.0	2400.0	35.0	-1.0	20.0	1.50	222233
30.0	-63.45	1467.0	127.70	38.99	2.908	0.20	1.15	1.30	80.0	40000.0	2400.0	35.0	-1.0	20.0	1.50	111111
31.0	12.53	2277.0	117.90	116.60	2.188	0.20	1.15	0.70	80.0	40000.0	2400.0	35.0	-1.0	20.0	1.50	222233
32.0	124.10	2277.0	108.10	91.26	2.319	0.20	1.15	0.70	80.0	80000.0	2400.0	35.0	-1.0	20.0	1.50	111111
33.0	26.86	3321.0	140.50	102.92	1.746	0.20	1.15	0.70	120.0	40000.0	2400.0	35.0	-1.0	20.0	1.50	111111
34.0	198.10	3321.0	126.50	83.63	1.847	0.20	1.15	0.70	120.0	80000.0	2400.0	35.0	-1.0	20.0	1.50	222333
35.0	82.89	2019.0	125.80	51.16	2.377	0.20	1.07	1.00	100.0	60000.0	2400.0	35.0	-1.0	20.0	1.50	200000
36.0	-40.58	1477.0	125.20	45.79	2.961	0.20	1.00	1.30	80.0	40000.0	2400.0	35.0	-1.0	20.0	1.50	222233
37.0	66.26	1477.0	115.50	40.68	3.095	0.20	1.00	1.30	80.0	80000.0	2400.0	35.0	-1.0	20.0	1.50	111111
38.0	-49.61	1923.0	150.00	43.20	2.338	0.20	1.00	1.30	120.0	40000.0	2400.0	35.0	-1.0	20.0	1.50	111111
39.0	91.61	1923.0	136.30	38.74	2.441	0.20	1.00	1.30	120.0	80000.0	2400.0	35.0	-1.0	20.0	1.50	222333
40.0	149.10	3384.0	124.50	108.68	1.869	0.20	1.00	0.70	120.0	80000.0	2400.0	35.0	-1.0	20.0	1.50	111111
41.0	11.91	3384.0	138.70	152.89	1.768	0.20	1.00	0.70	120.0	40000.0	2400.0	35.0	-1.0	20.0	1.50	222333
42.0	94.18	2302.0	106.60	124.20	2.347	0.20	1.00	0.70	80.0	80000.0	2400.0	35.0	-1.0	20.0	1.50	222233
43.0	-0.10	2058.0	117.90	120.82	2.364	0.20	1.00	0.80	80.0	40000.0	2400.0	35.0	-1.0	20.0	1.50	111111
44.0	79.51	2014.0	125.20	51.80	2.378	0.20	1.07	1.00	100.0	60000.0	2700.0	35.0	-1.0	20.0	1.50	020000
45.0	86.25	2059.0	123.20	57.49	2.444	1.00	1.00	1.00	100.0	60000.0	2700.0	35.0	-1.0	20.0	1.50	020000
46.0	108.90	2790.0	118.80	88.74	2.018	1.00	1.07	0.70	100.0	60000.0	2700.0	35.0	-1.0	20.0	1.50	020000
47.0	72.36	1730.0	113.20	50.72	2.681	1.00	1.07	1.00	80.0	60000.0	2700.0	35.0	-1.0	20.0	1.50	020000
48.0	10.47	2033.0	132.00	53.21	2.312	1.00	1.07	1.00	100.0	40000.0	2700.0	35.0	-1.0	20.0	1.50	020000
49.0	93.87	2033.0	123.90	48.82	2.390	1.00	1.07	1.00	100.0	60000.0	2700.0	35.0	-1.0	20.0	1.50	022000
50.0	142.80	2033.0	119.90	47.12	2.429	1.00	1.07	1.00	100.0	80000.0	2700.0	35.0	-1.0	20.0	1.50	020000

N	RANGE DASH(NM)	TO DIST (FT)	VEL (FT/SEC)	TIME (SEC)	G-LOAD	BPR	TR	T/W	W/S	GW (LBS)	T4 (DEGREES)	SWEEP (DEGREES)	AB	OPR	AR	ID
51.0	108.30	2360.0	134.00	48.10	2.156	1.00	1.07	1.00	120.0	60000.0	2700.0	35.0	-1.0	20.0	1.50	020000
52.0	63.48	1678.0	128.70	34.03	2.667	1.00	1.07	1.30	100.0	60000.0	2700.0	35.0	-1.0	20.0	1.50	020000
53.0	93.10	2042.0	125.90	47.81	2.385	1.00	1.15	1.00	100.0	60000.0	2700.0	35.0	-1.0	20.0	1.50	020000
54.0	91.18	2055.0	124.00	46.80	2.386	1.80	1.07	1.00	100.0	60000.0	2700.0	35.0	-1.0	20.0	1.50	020000
55.0	-2.21	2053.0	117.00	125.78	2.375	0.36	1.00	0.80	80.0	40000.0	3000.0	35.0	-1.0	20.0	1.50	022322
56.0	93.29	2296.0	105.60	128.45	2.357	0.36	1.00	0.70	80.0	80000.0	3000.0	35.0	-1.0	20.0	1.50	011111
57.0	4.31	3374.0	137.70	162.97	1.776	0.36	1.00	0.70	120.0	40000.0	3000.0	35.0	-1.0	20.0	1.50	011111
58.0	148.00	3374.0	123.30	111.85	1.877	0.36	1.00	0.70	120.0	80000.0	3000.0	35.0	-1.0	20.0	1.50	022222
59.0	-35.20	1475.0	123.60	46.22	2.979	0.36	1.00	1.30	80.0	40000.0	3000.0	35.0	-1.0	20.0	1.50	011111
60.0	69.39	1475.0	113.80	41.00	3.114	0.36	1.00	1.30	80.0	80000.0	3000.0	35.0	-1.0	20.0	1.50	022322
61.0	-39.16	1918.0	148.00	43.49	2.352	0.36	1.00	1.30	120.0	40000.0	3000.0	35.0	-1.0	20.0	1.50	022222
62.0	92.96	1918.0	134.10	38.99	2.456	0.36	1.00	1.30	120.0	80000.0	3000.0	35.0	-1.0	20.0	1.50	011111
63.0	8.62	2264.0	117.40	122.80	2.189	0.20	1.15	0.70	80.0	40000.0	3000.0	35.0	-1.0	20.0	1.50	011111
64.0	126.00	2264.0	107.60	94.57	2.320	0.20	1.15	0.70	80.0	80000.0	3000.0	35.0	-1.0	20.0	1.50	022322
65.0	21.37	3300.0	139.90	107.53	1.747	0.20	1.15	0.70	120.0	40000.0	3000.0	35.0	-1.0	20.0	1.50	022222
66.0	182.70	3300.0	125.80	86.54	1.848	0.20	1.15	0.70	120.0	80000.0	3000.0	35.0	-1.0	20.0	1.50	011111
67.0	-58.38	1462.0	126.80	39.17	2.925	0.20	1.15	1.30	80.0	40000.0	3000.0	35.0	-1.0	20.0	1.50	022322
68.0	41.32	1462.0	117.20	35.40	3.059	0.20	1.15	1.30	80.0	80000.0	3000.0	35.0	-1.0	20.0	1.50	011111
69.0	-65.16	1888.0	152.00	37.55	2.311	0.20	1.15	1.30	120.0	40000.0	3000.0	35.0	-1.0	20.0	1.50	011111
70.0	59.66	1888.0	138.30	34.07	2.413	0.20	1.15	1.30	120.0	80000.0	3000.0	35.0	-1.0	20.0	1.50	022222
71.0	94.94	2028.0	123.30	49.28	2.393	1.00	1.07	1.00	100.0	60000.0	3000.0	35.0	-1.0	20.0	1.50	020000
72.0	13.45	2325.0	115.40	149.72	2.283	1.80	1.00	0.70	80.0	40000.0	3000.0	35.0	-1.0	20.0	1.50	011111
73.0	106.00	2325.0	105.40	108.40	2.410	1.80	1.00	0.70	80.0	80000.0	3000.0	35.0	-1.0	20.0	1.50	022232
74.0	31.43	3417.0	137.50	122.65	1.818	1.80	1.00	0.70	120.0	40000.0	3000.0	35.0	-1.0	20.0	1.50	022332
75.0	152.40	3417.0	123.20	96.37	1.923	1.80	1.00	0.70	120.0	80000.0	3000.0	35.0	-1.0	20.0	1.50	011111
76.0	-19.45	1487.0	123.60	42.80	3.028	1.80	1.00	1.30	80.0	40000.0	3000.0	35.0	-1.0	20.0	1.50	022232
77.0	69.36	1487.0	113.70	38.48	3.163	1.80	1.00	1.30	80.0	80000.0	3000.0	35.0	-1.0	20.0	1.50	011111
78.0	-22.97	1936.0	148.20	40.64	2.382	1.80	1.00	1.30	120.0	40000.0	3000.0	35.0	-1.0	20.0	1.50	011111
79.0	105.50	1936.0	134.10	36.18	2.493	1.80	1.00	1.30	120.0	80000.0	3000.0	35.0	-1.0	20.0	1.50	022332
80.0	21.10	2318.0	116.70	99.36	2.201	1.80	1.15	0.70	80.0	40000.0	3000.0	35.0	-1.0	20.0	1.50	022232
81.0	126.10	2318.0	106.80	81.58	2.331	1.80	1.15	0.70	80.0	80000.0	3000.0	35.0	-1.0	20.0	1.50	011111
82.0	37.33	3390.0	139.20	90.00	1.753	1.80	1.15	0.70	120.0	40000.0	3000.0	35.0	-1.0	20.0	1.50	011111
83.0	159.50	3390.0	125.00	75.96	1.853	1.80	1.15	0.70	120.0	80000.0	3000.0	35.0	-1.0	20.0	1.50	022332
84.0	-40.03	1484.0	126.00	35.72	2.920	1.80	1.15	1.30	80.0	40000.0	3000.0	35.0	-1.0	20.0	1.50	011111
85.0	68.64	1484.0	116.10	32.71	3.052	1.80	1.15	1.30	80.0	80000.0	3000.0	35.0	-1.0	20.0	1.50	022232
86.0	-53.14	1925.0	151.30	34.55	2.301	1.80	1.15	1.30	120.0	40000.0	3000.0	35.0	-1.0	20.0	1.50	022332
87.0	91.54	1925.0	137.30	31.79	2.401	1.80	1.15	1.30	120.0	80000.0	3000.0	35.0	-1.0	20.0	1.50	011111
88.0	95.00	2613.0	145.60	45.61	2.421	1.00	1.07	1.00	100.0	60000.0	2400.0	50.0	-1.0	20.0	1.50	002000
89.0	84.84	2573.0	145.50	48.96	2.418	0.20	1.07	1.00	100.0	60000.0	2700.0	50.0	-1.0	20.0	1.50	002000
90.0	96.17	2648.0	143.30	54.00	2.473	1.00	1.00	1.00	100.0	60000.0	2700.0	50.0	-1.0	20.0	1.50	002000
91.0	124.70	3736.0	138.20	80.46	2.097	1.00	1.07	0.70	100.0	60000.0	2700.0	50.0	-1.0	20.0	1.50	002000
92.0	80.92	2149.0	131.80	47.48	2.779	1.00	1.07	1.00	80.0	60000.0	2700.0	50.0	-1.0	20.0	1.50	002000
93.0	12.51	2601.0	153.10	50.22	2.354	1.00	1.07	1.00	100.0	40000.0	2700.0	50.0	-1.0	20.0	1.50	002000
94.0	105.50	2601.0	144.10	46.33	2.427	1.00	1.07	1.00	100.0	60000.0	2700.0	50.0	-1.0	20.0	1.50	002300
95.0	161.20	2601.0	139.60	44.78	2.464	1.00	1.07	1.00	100.0	80000.0	2700.0	50.0	-1.0	20.0	1.50	002000
96.0	121.00	3086.0	155.60	46.01	2.158	1.00	1.07	1.00	120.0	60000.0	2700.0	50.0	-1.0	20.0	1.50	002000
97.0	67.06	2068.0	149.60	32.84	2.655	1.00	1.07	1.30	100.0	60000.0	2700.0	50.0	-1.0	20.0	1.50	002000
98.0	103.80	2613.0	146.30	45.43	2.421	1.00	1.15	1.00	100.0	60000.0	2700.0	50.0	-1.0	20.0	1.50	002000
99.0	100.70	2633.0	144.20	44.50	2.423	1.80	1.07	1.00	100.0	60000.0	2700.0	50.0	-1.0	20.0	1.50	002000
100.0	107.20	2594.0	143.40	46.73	2.431	1.00	1.07	1.00	100.0	60000.0	3000.0	50.0	-1.0	20.0	1.50	002000

N	RANGE DASH(NM)	TD DIST (FT)	VEL (FT/SEC)	TIME (SEC)	G-LOAD	BPR	TR	T/W	W/S	GW (LBS)	T4 (DEGREES)	SWEEP (DEGREES)	AB	OPR	AR	ID
101.0	3.35	4697.0	169.90	127.30	2.248	0.20	1.00	0.70	80.0	40000.0	2400.0	65.0	-1.0	20.0	1.50	002322
102.0	126.40	4697.0	157.80	93.35	2.367	0.20	1.00	0.70	80.0	80000.0	2400.0	65.0	-1.0	20.0	1.50	001111
103.0	19.49	7554.0	201.00	121.39	1.760	0.20	1.00	0.70	120.0	40000.0	2400.0	65.0	-1.0	20.0	1.50	001111
104.0	185.30	7554.0	182.60	91.98	1.849	0.20	1.00	0.70	120.0	80000.0	2400.0	65.0	-1.0	20.0	1.50	002222
105.0	-69.64	2463.0	182.20	41.62	2.844	0.20	1.00	1.30	80.0	40000.0	2400.0	65.0	-1.0	20.0	1.50	001111
106.0	49.79	2463.0	170.20	37.40	2.959	0.20	1.00	1.30	80.0	80000.0	2400.0	65.0	-1.0	20.0	1.50	002322
107.0	-65.31	3639.0	216.80	40.79	2.210	0.20	1.00	1.30	120.0	40000.0	2400.0	65.0	-1.0	20.0	1.50	002222
108.0	83.49	3639.0	198.90	36.79	2.302	0.20	1.00	1.30	120.0	80000.0	2400.0	65.0	-1.0	20.0	1.50	001111
109.0	4.80	4578.0	171.90	91.73	2.223	0.20	1.15	0.70	80.0	40000.0	2400.0	65.0	-1.0	20.0	1.50	001111
110.0	161.10	4578.0	159.90	75.31	2.341	0.20	1.15	0.70	80.0	80000.0	2400.0	65.0	-1.0	20.0	1.50	002322
111.0	25.08	7279.0	203.50	89.60	1.741	0.20	1.15	0.70	120.0	40000.0	2400.0	65.0	-1.0	20.0	1.50	002222
112.0	222.60	7279.0	185.40	74.52	1.830	0.20	1.15	0.70	120.0	80000.0	2400.0	65.0	-1.0	20.0	1.50	001111
113.0	-90.99	2414.0	185.70	36.14	2.799	0.20	1.15	1.30	80.0	40000.0	2400.0	65.0	-1.0	20.0	1.50	002322
114.0	24.69	2414.0	173.90	32.54	2.920	0.20	1.15	1.30	80.0	80000.0	2400.0	65.0	-1.0	20.0	1.50	001111
115.0	-88.93	3526.0	221.30	35.25	2.177	0.20	1.15	1.30	120.0	40000.0	2400.0	65.0	-1.0	20.0	1.50	001111
116.0	52.97	3526.0	203.80	32.16	2.269	0.20	1.15	1.30	120.0	80000.0	2400.0	65.0	-1.0	20.0	1.50	002222
117.0	17.84	4780.0	169.40	99.18	2.301	1.80	1.00	0.70	80.0	40000.0	2400.0	65.0	-1.0	20.0	1.50	001111
118.0	127.70	4780.0	157.30	80.28	2.418	1.80	1.00	0.70	80.0	80000.0	2400.0	65.0	-1.0	20.0	1.50	002232
119.0	34.77	7662.0	200.60	95.36	1.794	1.80	1.00	0.70	120.0	40000.0	2400.0	65.0	-1.0	20.0	1.50	002332
120.0	179.20	7662.0	182.10	79.20	1.881	1.80	1.00	0.70	120.0	80000.0	2400.0	65.0	-1.0	20.0	1.50	001111
121.0	-41.19	2497.0	181.80	37.55	2.885	1.80	1.00	1.30	80.0	40000.0	2400.0	65.0	-1.0	20.0	1.50	002232
122.0	58.92	2497.0	169.50	34.24	2.999	1.80	1.00	1.30	80.0	80000.0	2400.0	65.0	-1.0	20.0	1.50	001111
123.0	-39.94	3684.0	216.50	37.01	2.241	1.80	1.00	1.30	120.0	40000.0	2400.0	65.0	-1.0	20.0	1.50	001111
124.0	89.14	3684.0	198.30	33.92	2.331	1.80	1.00	1.30	120.0	80000.0	2400.0	65.0	-1.0	20.0	1.50	002332
125.0	4.06	4753.0	172.50	80.60	2.197	1.80	1.15	0.70	80.0	40000.0	2400.0	65.0	-1.0	20.0	1.50	002232
126.0	123.00	4753.0	160.40	68.90	2.313	1.80	1.15	0.70	80.0	80000.0	2400.0	65.0	-1.0	20.0	1.50	001111
127.0	21.25	7551.0	204.40	80.06	1.719	1.80	1.15	0.70	120.0	40000.0	2400.0	65.0	-1.0	20.0	1.50	001111
128.0	190.20	7552.0	186.30	66.92	1.815	1.80	1.15	0.70	120.0	80000.0	2400.0	65.0	-1.0	20.0	1.50	002332
129.0	-85.18	2486.0	186.90	32.65	2.773	1.80	1.15	1.30	80.0	40000.0	2400.0	65.0	-1.0	20.0	1.50	001111
130.0	31.70	2486.0	174.80	30.19	2.884	1.80	1.15	1.30	80.0	80000.0	2400.0	65.0	-1.0	20.0	1.50	002232
131.0	-94.63	3638.0	223.20	32.50	2.145	1.80	1.15	1.30	120.0	40000.0	2400.0	65.0	-1.0	20.0	1.50	002332
132.0	59.31	3638.0	205.20	30.14	2.231	1.80	1.15	1.30	120.0	80000.0	2400.0	65.0	-1.0	20.0	1.50	001111
133.0	105.50	2601.0	144.10	46.33	2.427	1.00	1.07	1.00	100.0	60000.0	2700.0	50.0	-1.0	20.0	1.50	002000
134.0	1.41	4682.0	168.80	132.98	2.258	0.36	1.00	0.70	80.0	40000.0	3000.0	65.0	-1.0	20.0	1.50	001111
135.0	127.60	4682.0	156.50	95.15	2.377	0.36	1.00	0.70	80.0	80000.0	3000.0	65.0	-1.0	20.0	1.50	002233
136.0	17.45	7525.0	199.60	126.40	1.767	0.36	1.00	0.70	120.0	40000.0	3000.0	65.0	-1.0	20.0	1.50	002333
137.0	184.20	7525.0	180.90	93.78	1.857	0.36	1.00	0.70	120.0	80000.0	3000.0	65.0	-1.0	20.0	1.50	001111
138.0	-57.56	2457.0	179.90	41.94	2.861	0.36	1.00	1.30	80.0	40000.0	3000.0	65.0	-1.0	20.0	1.50	002233
139.0	55.31	2457.0	167.80	37.62	2.976	0.36	1.00	1.30	80.0	80000.0	3000.0	65.0	-1.0	20.0	1.50	001111
140.0	-53.83	3628.0	214.00	41.04	2.223	0.36	1.00	1.30	120.0	40000.0	3000.0	65.0	-1.0	20.0	1.50	001111
141.0	86.60	3628.0	195.90	37.01	2.316	0.36	1.00	1.30	120.0	80000.0	3000.0	65.0	-1.0	20.0	1.50	002333
142.0	-0.44	4547.0	171.20	95.15	2.224	0.20	1.15	0.70	80.0	40000.0	3000.0	65.0	-1.0	20.0	1.50	002233
143.0	138.90	4547.0	159.20	77.29	2.342	0.20	1.15	0.70	80.0	80000.0	3000.0	65.0	-1.0	20.0	1.50	001111
144.0	17.92	7226.0	202.60	92.84	1.743	0.20	1.15	0.70	120.0	40000.0	3000.0	65.0	-1.0	20.0	1.50	001111
145.0	192.40	7226.0	184.40	76.57	1.832	0.20	1.15	0.70	120.0	80000.0	3000.0	65.0	-1.0	20.0	1.50	002333
146.0	-83.38	2402.0	184.40	36.79	2.807	0.20	1.15	1.30	80.0	40000.0	3000.0	65.0	-1.0	20.0	1.50	001111
147.0	21.86	2402.0	172.50	33.07	2.928	0.20	1.15	1.30	80.0	80000.0	3000.0	65.0	-1.0	20.0	1.50	002233
148.0	-81.97	3505.0	219.60	35.83	2.183	0.20	1.15	1.30	120.0	40000.0	3000.0	65.0	-1.0	20.0	1.50	002333
149.0	48.04	3505.0	201.80	32.67	2.275	0.20	1.15	1.30	120.0	80000.0	3000.0	65.0	-1.0	20.0	1.50	001111
150.0	16.64	4738.0	168.60	107.53	2.308	1.80	1.00	0.70	80.0	40000.0	3000.0	65.0	-1.0	20.0	1.50	002323

N	RANGE DASH(NM)	TO DIST (FT)	VEL (FT/SEC)	TIME (SEC)	G-LOAD	BPR	TR	T/W	W/S	GW (LBS)	T4 (DEGREES)	SWEEP (DEGREES)	AB	OPR	AR	ID
151.0	131.20	4738.0	156.30	84.78	2.425	1.80	1.00	0.70	80.0	80000.0	3000.0	65.0	-1.0	20.0	1.50	001111
152.0	33.89	7598.0	199.30	102.64	1.799	1.80	1.00	0.70	120.0	40000.0	3000.0	65.0	-1.0	20.0	1.50	001111
153.0	183.30	7598.0	180.80	83.34	1.887	1.80	1.00	0.70	120.0	80000.0	3000.0	65.0	-1.0	20.0	1.50	002223
154.0	-39.57	2480.0	180.00	39.17	2.898	1.80	1.00	1.30	80.0	40000.0	3000.0	65.0	-1.0	20.0	1.50	001111
155.0	66.97	2480.0	167.80	35.51	3.012	1.80	1.00	1.30	80.0	80000.0	3000.0	65.0	-1.0	20.0	1.50	002323
156.0	-38.04	3658.0	214.30	38.52	2.252	1.80	1.00	1.30	120.0	40000.0	3000.0	65.0	-1.0	20.0	1.50	002223
157.0	114.10	3658.0	196.00	34.50	2.352	1.80	1.00	1.30	120.0	80000.0	3000.0	65.0	-1.0	20.0	1.50	001111
158.0	11.05	4675.0	170.50	83.99	2.221	1.80	1.15	0.70	80.0	40000.0	3000.0	65.0	-1.0	20.0	1.50	001111
159.0	148.20	4675.0	158.40	68.90	2.350	1.80	1.15	0.70	80.0	80000.0	3000.0	65.0	-1.0	20.0	1.50	002323
160.0	35.56	7428.0	201.60	80.03	1.747	1.80	1.15	0.70	120.0	40000.0	3000.0	65.0	-1.0	20.0	1.50	002223
161.0	212.00	7428.0	183.50	68.58	1.834	1.80	1.15	0.70	120.0	80000.0	3000.0	65.0	-1.0	20.0	1.50	001111
162.0	-74.06	2454.0	183.40	33.39	2.809	1.80	1.15	1.30	80.0	40000.0	3000.0	65.0	-1.0	20.0	1.50	002323
163.0	51.66	2454.0	171.10	30.74	2.921	1.80	1.15	1.30	80.0	80000.0	3000.0	65.0	-1.0	20.0	1.50	001111
164.0	-74.92	3588.0	218.60	33.15	2.174	1.80	1.15	1.30	120.0	40000.0	3000.0	65.0	-1.0	20.0	1.50	001111
165.0	78.21	3588.0	200.50	30.59	2.263	1.80	1.15	1.30	120.0	80000.0	3000.0	65.0	-1.0	20.0	1.50	002223
166.0	-2.37	2293.0	117.00	180.83	2.206	0.20	1.00	0.70	80.0	40000.0	2400.0	35.0	1.0	20.0	1.50	000322
167.0	102.60	2293.0	107.20	121.18	2.337	0.20	1.00	0.70	80.0	80000.0	2400.0	35.0	1.0	20.0	1.50	000111
168.0	17.45	3364.0	139.50	142.99	1.760	0.20	1.00	0.70	120.0	40000.0	2400.0	35.0	1.0	20.0	1.50	000111
169.0	154.70	3364.0	125.40	106.27	1.861	0.20	1.00	0.70	120.0	80000.0	2400.0	35.0	1.0	20.0	1.50	000222
170.0	-52.52	1473.0	126.30	46.30	2.938	0.20	1.00	1.30	80.0	40000.0	2400.0	35.0	1.0	20.0	1.50	000111
171.0	51.50	1473.0	116.70	41.22	3.071	0.20	1.00	1.30	80.0	80000.0	2400.0	35.0	1.0	20.0	1.50	000322
172.0	-64.78	1915.0	151.40	43.81	2.319	0.20	1.00	1.30	120.0	40000.0	2400.0	35.0	1.0	20.0	1.50	000222
173.0	72.05	1915.0	137.80	39.35	2.421	0.20	1.00	1.30	120.0	80000.0	2400.0	35.0	1.0	20.0	1.50	000111
174.0	4.83	2274.0	118.70	131.54	2.151	0.20	1.15	0.70	80.0	40000.0	2400.0	35.0	1.0	20.0	1.50	000111
175.0	102.90	2274.0	109.00	101.20	2.279	0.20	1.15	0.70	80.0	80000.0	2400.0	35.0	1.0	20.0	1.50	000322
176.0	14.00	3317.0	141.50	114.48	1.716	0.20	1.15	0.70	120.0	40000.0	2400.0	35.0	1.0	20.0	1.50	000222
177.0	172.40	3317.0	127.70	88.34	1.827	0.20	1.15	0.70	120.0	80000.0	2400.0	35.0	1.0	20.0	1.50	000111
178.0	-74.97	1466.0	129.20	40.75	2.876	0.20	1.15	1.30	80.0	40000.0	2400.0	35.0	1.0	20.0	1.50	000322
179.0	26.81	1466.0	119.80	36.83	3.006	0.20	1.15	1.30	80.0	80000.0	2400.0	35.0	1.0	20.0	1.50	000111
180.0	-84.33	1895.0	155.10	39.13	2.271	0.20	1.15	1.30	120.0	40000.0	2400.0	35.0	1.0	20.0	1.50	000111
181.0	41.58	1895.0	141.60	35.54	2.371	0.20	1.15	1.30	120.0	80000.0	2400.0	35.0	1.0	20.0	1.50	000222
182.0	11.01	2336.0	116.40	148.50	2.259	1.80	1.00	0.70	80.0	40000.0	2400.0	35.0	1.0	20.0	1.50	000111
183.0	86.92	2336.0	106.50	110.66	2.383	1.80	1.00	0.70	80.0	80000.0	2400.0	35.0	1.0	20.0	1.50	000232
184.0	24.07	3435.0	138.90	122.72	1.796	1.80	1.00	0.70	120.0	40000.0	2400.0	35.0	1.0	20.0	1.50	000332
185.0	116.20	2993.0	126.90	76.36	2.026	1.80	1.00	0.80	120.0	80000.0	2400.0	35.0	1.0	20.0	1.50	000111
186.0	-24.15	1491.0	125.60	42.12	3.005	1.80	1.00	1.30	80.0	40000.0	2400.0	35.0	1.0	20.0	1.50	000232
187.0	48.77	1491.0	115.70	38.16	3.137	1.80	1.00	1.30	80.0	80000.0	2400.0	35.0	1.0	20.0	1.50	000111
188.0	-29.06	1944.0	150.70	40.14	2.363	1.80	1.00	1.30	120.0	40000.0	2400.0	35.0	1.0	20.0	1.50	000111
189.0	64.99	1944.0	136.80	36.68	2.462	1.80	1.00	1.30	120.0	80000.0	2400.0	35.0	1.0	20.0	1.50	000332
190.0	11.30	2339.0	118.20	100.04	2.191	1.80	1.15	0.70	80.0	40000.0	2400.0	35.0	1.0	20.0	1.50	000232
191.0	100.70	2339.0	108.40	82.87	2.318	1.80	1.15	0.70	80.0	80000.0	2400.0	35.0	1.0	20.0	1.50	000111
192.0	21.22	3422.0	141.30	91.12	1.743	1.80	1.15	0.70	120.0	40000.0	2400.0	35.0	1.0	20.0	1.50	000111
193.0	104.70	3422.0	127.20	77.62	1.839	1.80	1.15	0.70	120.0	80000.0	2400.0	35.0	1.0	20.0	1.50	000332
194.0	-47.39	1492.0	128.60	35.20	2.914	1.80	1.15	1.30	80.0	40000.0	2400.0	35.0	1.0	20.0	1.50	000111
195.0	40.44	1492.0	118.80	32.39	3.043	1.80	1.15	1.30	80.0	80000.0	2400.0	35.0	1.0	20.0	1.50	000232
196.0	-60.11	1938.0	154.70	34.12	2.293	1.80	1.15	1.30	120.0	40000.0	2400.0	35.0	1.0	20.0	1.50	000332
197.0	29.63	1938.0	140.90	31.59	2.389	1.80	1.15	1.30	120.0	80000.0	2400.0	35.0	1.0	20.0	1.50	000111
198.0	2.11	4663.0	170.80	121.72	2.240	0.20	1.00	0.70	80.0	40000.0	2400.0	65.0	1.0	20.0	1.50	000111
199.0	128.00	4663.0	158.70	92.27	2.358	0.20	1.00	0.70	80.0	80000.0	2400.0	65.0	1.0	20.0	1.50	000233
200.0	18.01	7483.0	202.10	116.03	1.753	0.20	1.00	0.70	120.0	40000.0	2400.0	65.0	1.0	20.0	1.50	000333
201.0	192.60	7483.0	183.90	90.61	1.842	0.20	1.00	0.70	120.0	80000.0	2400.0	65.0	1.0	20.0	1.50	000111

N	RANGE DASH(NM)	TO DIST (FT)	VEL (FT/SEC)	TIME (SEC)	G-LOAD	BPR	TR	T/W	W/S	GW (LBS)	T4 (DEGREES)	SWEEP (DEGREES)	AB	OPR	AR	ID
202.0	-84.00	2450.0	183.80	42.05	2.825	0.20	1.00	1.30	80.0	40000.0	2400.0	65.0	1.0	20.0	1.50	000233
203.0	31.72	2450.0	171.90	37.80	2.938	0.20	1.00	1.30	80.0	80000.0	2400.0	65.0	1.0	20.0	1.50	000111
204.0	-83.15	3610.0	218.90	41.33	2.192	0.20	1.00	1.30	120.0	40000.0	2400.0	65.0	1.0	20.0	1.50	000111
205.0	60.37	3610.0	201.10	37.33	2.283	0.20	1.00	1.30	120.0	80000.0	2400.0	65.0	1.0	20.0	1.50	000333
206.0	-5.92	4571.0	173.00	100.26	2.190	0.20	1.15	0.70	80.0	40000.0	2400.0	65.0	1.0	20.0	1.50	000233
207.0	124.70	4571.0	161.20	81.58	2.307	0.20	1.15	0.70	80.0	80000.0	2400.0	65.0	1.0	20.0	1.50	000111
208.0	8.33	7268.0	204.90	98.03	1.716	0.20	1.15	0.70	120.0	40000.0	2400.0	65.0	1.0	20.0	1.50	000111
209.0	186.10	7268.0	187.10	81.07	1.804	0.20	1.15	0.70	120.0	80000.0	2400.0	65.0	1.0	20.0	1.50	000333
210.0	-102.70	2412.0	187.70	37.66	2.772	0.20	1.15	1.30	80.0	40000.0	2400.0	65.0	1.0	20.0	1.50	000111
211.0	2.72	2412.0	176.00	34.27	2.884	0.20	1.15	1.30	80.0	80000.0	2400.0	65.0	1.0	20.0	1.50	000233
212.0	-103.60	3522.0	223.90	37.26	2.148	0.20	1.15	1.30	120.0	40000.0	2400.0	65.0	1.0	20.0	1.50	000333
213.0	25.25	3522.0	206.50	34.00	2.236	0.20	1.15	1.30	120.0	80000.0	2400.0	65.0	1.0	20.0	1.50	000111
214.0	9.22	4765.0	170.10	107.42	2.285	1.80	1.00	0.70	80.0	40000.0	2400.0	65.0	1.0	20.0	1.50	000323
215.0	101.50	4765.0	157.90	86.18	2.400	1.80	1.00	0.70	80.0	80000.0	2400.0	65.0	1.0	20.0	1.50	000111
216.0	24.05	7639.0	201.20	103.00	1.781	1.80	1.00	0.70	120.0	40000.0	2400.0	65.0	1.0	20.0	1.50	000111
217.0	141.00	7640.0	183.00	85.07	1.867	1.80	1.00	0.70	120.0	80000.0	2400.0	65.0	1.0	20.0	1.50	000223
218.0	-42.07	2491.0	182.80	38.66	2.876	1.80	1.00	1.30	80.0	40000.0	2400.0	65.0	1.0	20.0	1.50	000111
219.0	40.41	2491.0	170.60	35.25	2.989	1.80	1.00	1.30	80.0	80000.0	2400.0	65.0	1.0	20.0	1.50	000323
220.0	-42.45	3675.0	217.90	38.12	2.233	1.80	1.00	1.30	120.0	40000.0	2400.0	65.0	1.0	20.0	1.50	000223
221.0	61.39	3675.0	199.80	34.93	2.322	1.80	1.00	1.30	120.0	80000.0	2400.0	65.0	1.0	20.0	1.50	000111
222.0	0.31	4719.0	172.50	81.76	2.224	1.80	1.15	0.70	80.0	40000.0	2400.0	65.0	1.0	20.0	1.50	000111
223.0	112.60	4719.0	160.40	69.73	2.338	1.80	1.15	0.70	80.0	80000.0	2400.0	65.0	1.0	20.0	1.50	000323
224.0	17.79	7491.0	204.50	80.89	1.737	1.80	1.15	0.70	120.0	40000.0	2400.0	65.0	1.0	20.0	1.50	000223
225.0	157.00	7491.0	186.40	69.88	1.822	1.80	1.15	0.70	120.0	80000.0	2400.0	65.0	1.0	20.0	1.50	000111
226.0	-78.15	2472.0	187.10	32.97	2.800	1.80	1.15	1.30	80.0	40000.0	2400.0	65.0	1.0	20.0	1.50	000323
227.0	24.31	2472.0	175.00	30.47	2.910	1.80	1.15	1.30	80.0	80000.0	2400.0	65.0	1.0	20.0	1.50	000111
228.0	-85.44	3614.0	223.40	32.77	2.166	1.80	1.15	1.30	120.0	40000.0	2400.0	65.0	1.0	20.0	1.50	000111
229.0	47.30	3614.0	205.50	30.41	2.252	1.80	1.15	1.30	120.0	80000.0	2400.0	65.0	1.0	20.0	1.50	000223
230.0	94.76	2610.0	145.70	45.94	2.420	1.00	1.07	1.00	100.0	60000.0	2400.0	50.0	0.0	20.0	1.50	000300
231.0	73.09	2595.0	145.40	49.03	2.402	1.00	1.07	1.00	100.0	60000.0	2700.0	50.0	1.0	20.0	1.50	000300
232.0	94.42	2031.0	124.10	49.00	2.389	1.00	1.07	1.00	100.0	60000.0	2700.0	35.0	0.0	20.0	1.50	000300
233.0	84.82	2573.0	145.70	49.03	2.416	0.20	1.07	1.00	100.0	60000.0	2700.0	50.0	0.0	20.0	1.50	000300
234.0	101.50	2651.0	143.40	54.14	2.470	1.00	1.00	1.00	100.0	60000.0	2700.0	50.0	0.0	20.0	1.50	00030.
235.0	127.70	3731.0	138.30	80.68	2.097	1.00	1.07	0.70	100.0	60000.0	2700.0	50.0	0.0	20.0	1.50	000300
236.0	81.27	2147.0	131.90	47.63	2.778	1.00	1.07	1.00	80.0	60000.0	2700.0	50.0	0.0	20.0	1.50	000300
237.0	11.08	2598.0	153.30	50.40	2.354	1.00	1.07	1.00	100.0	40000.0	2700.0	50.0	0.0	20.0	1.50	000300
238.0	106.20	2598.0	144.20	46.48	2.426	1.00	1.07	1.00	100.0	60000.0	2700.0	50.0	0.0	20.0	1.50	000330
239.0	163.60	2598.0	139.80	44.93	2.463	1.00	1.07	1.00	100.0	80000.0	2700.0	50.0	0.0	20.0	1.50	000300
240.0	122.40	3081.0	155.80	46.15	2.157	1.00	1.07	1.00	120.0	60000.0	2700.0	50.0	0.0	20.0	1.50	000300
241.0	60.90	2066.0	149.80	33.43	2.646	1.00	1.07	1.30	100.0	60000.0	2700.0	50.0	0.0	20.0	1.50	000300
242.0	90.56	2610.0	146.60	46.87	2.410	1.00	1.15	1.00	100.0	60000.0	2700.0	50.0	0.0	20.0	1.50	000300
243.0	89.22	2625.0	144.30	45.68	2.415	1.80	1.07	1.00	100.0	60000.0	2700.0	50.0	0.0	20.0	1.50	000300
244.0	106.00	3899.0	181.40	45.36	2.306	1.00	1.07	1.00	100.0	60000.0	2700.0	65.0	0.0	20.0	1.50	000300
245.0	-9.56	2287.0	116.40	192.71	2.215	0.36	1.00	0.70	80.0	40000.0	3000.0	35.0	1.0	20.0	1.50	000111
246.0	97.32	2287.0	106.50	125.50	2.345	0.36	1.00	0.70	80.0	80000.0	3000.0	35.0	1.0	20.0	1.50	000233
247.0	13.23	3355.0	138.80	148.21	1.767	0.36	1.00	0.70	120.0	40000.0	3000.0	35.0	1.0	20.0	1.50	000333
248.0	144.80	3355.0	124.50	109.08	1.868	0.36	1.00	0.70	120.0	80000.0	3000.0	35.0	1.0	20.0	1.50	000111
249.0	-48.00	1471.0	125.10	47.05	2.953	0.36	1.00	1.30	80.0	40000.0	3000.0	35.0	1.0	20.0	1.50	000233
250.0	50.25	1471.0	115.40	41.83	3.085	0.36	1.00	1.30	80.0	80000.0	3000.0	35.0	1.0	20.0	1.50	000111
251.0	-59.50	1911.0	150.10	44.42	2.330	0.36	1.00	1.30	120.0	40000.0	3000.0	35.0	1.0	20.0	1.50	000111
252.0	67.32	1911.0	136.30	39.89	2.432	0.36	1.00	1.30	120.0	80000.0	3000.0	35.0	1.0	20.0	1.50	000333

N	RANGE DASH(NM)	TO DIST (FT)	VEL (FT/SEC)	TIME (SEC)	G-LOAD	BPR	TR	T/W	W/S	GW (LBS)	T4 (DEGREES)	SWEEP (DEGREES)	AB	OPR	AR	ID
253.0	0.83	2264.0	118.00	137.59	2.155	0.20	1.15	0.70	80.0	40000.0	3000.0	35.0	1.0	20.0	1.50	000233
254.0	104.80	2264.0	108.30	104.36	2.284	0.20	1.15	0.70	80.0	80000.0	3000.0	35.0	1.0	20.0	1.50	000111
255.0	12.25	3300.0	140.80	112.82	1.731	0.20	1.15	0.70	120.0	40000.0	3000.0	35.0	1.0	20.0	1.50	000111
256.0	167.40	3300.0	126.80	90.54	1.831	0.20	1.15	0.70	120.0	80000.0	3000.0	35.0	1.0	20.0	1.50	000333
257.0	-67.54	1462.0	128.00	41.47	2.888	0.20	1.15	1.30	80.0	40000.0	3000.0	35.0	1.0	20.0	1.50	000111
258.0	25.07	1462.0	118.40	37.37	3.019	0.20	1.15	1.30	80.0	80000.0	3000.0	35.0	1.0	20.0	1.50	000233
259.0	-79.04	1888.0	153.80	39.71	2.282	0.20	1.15	1.30	120.0	40000.0	3000.0	35.0	1.0	20.0	1.50	000333
260.0	35.88	1888.0	140.20	36.00	2.382	0.20	1.15	1.30	120.0	80000.0	3000.0	35.0	1.0	20.0	1.50	000111
261.0	6.35	2320.0	116.00	167.76	2.261	1.80	1.00	0.70	80.0	40000.0	3000.0	35.0	1.0	20.0	1.50	000323
262.0	86.04	2320.0	106.00	119.20	2.385	1.80	1.00	0.70	80.0	80000.0	3000.0	35.0	1.0	20.0	1.50	000111
263.0	20.16	3410.0	138.30	134.06	1.798	1.80	1.00	0.70	120.0	40000.0	3000.0	35.0	1.0	20.0	1.50	000111
264.0	121.40	3410.0	124.00	104.62	1.899	1.80	1.00	0.70	120.0	80000.0	3000.0	35.0	1.0	20.0	1.50	000223
265.0	-24.58	1485.0	124.70	44.06	3.013	1.80	1.00	1.30	80.0	40000.0	3000.0	35.0	1.0	20.0	1.50	000111
266.0	50.17	1485.0	114.80	39.60	3.146	1.80	1.00	1.30	80.0	80000.0	3000.0	35.0	1.0	20.0	1.50	000323
267.0	-29.89	1933.0	149.60	41.80	2.370	1.80	1.00	1.30	120.0	40000.0	3000.0	35.0	1.0	20.0	1.50	000223
268.0	67.97	1933.0	135.60	37.91	2.471	1.80	1.00	1.30	120.0	80000.0	3000.0	35.0	1.0	20.0	1.50	000111
269.0	15.83	2313.0	116.90	107.71	2.187	1.80	1.15	0.70	80.0	40000.0	3000.0	35.0	1.0	20.0	1.50	000111
270.0	108.90	2313.0	106.90	87.52	2.315	1.80	1.15	0.70	80.0	80000.0	3000.0	35.0	1.0	20.0	1.50	000323
271.0	27.92	3380.0	139.50	96.91	1.741	1.80	1.15	0.70	120.0	40000.0	3000.0	35.0	1.0	20.0	1.50	000223
272.0	143.60	3380.0	125.40	78.01	1.852	1.80	1.15	0.70	120.0	80000.0	3000.0	35.0	1.0	20.0	1.50	000111
273.0	-39.32	1482.0	126.30	36.54	2.920	1.80	1.15	1.30	80.0	40000.0	3000.0	35.0	1.0	20.0	1.50	000323
274.0	56.89	1482.0	116.40	33.44	3.051	1.80	1.15	1.30	80.0	80000.0	3000.0	35.0	1.0	20.0	1.50	000111
275.0	-50.83	1921.0	151.70	35.30	2.301	1.80	1.15	1.30	120.0	40000.0	3000.0	35.0	1.0	20.0	1.50	000111
276.0	80.25	1921.0	137.80	32.47	2.399	1.80	1.15	1.30	120.0	80000.0	3000.0	35.0	1.0	20.0	1.50	000223
277.0	-3.19	4648.0	170.00	131.80	2.237	0.36	1.00	0.70	80.0	40000.0	3000.0	65.0	1.0	20.0	1.50	000322
278.0	119.40	4648.0	157.70	94.32	2.366	0.36	1.00	0.70	80.0	80000.0	3000.0	65.0	1.0	20.0	1.50	000111
279.0	13.03	7455.0	201.10	119.02	1.759	0.36	1.00	0.70	120.0	40000.0	3000.0	65.0	1.0	20.0	1.50	000111
280.0	177.00	7455.0	182.70	92.45	1.848	0.36	1.00	0.70	120.0	80000.0	3000.0	65.0	1.0	20.0	1.50	000222
281.0	-76.04	2443.0	182.20	42.62	2.838	0.36	1.00	1.30	80.0	40000.0	3000.0	65.0	1.0	20.0	1.50	000111
282.0	31.99	2443.0	170.10	38.30	2.951	0.36	1.00	1.30	80.0	80000.0	3000.0	65.0	1.0	20.0	1.50	000322
283.0	-76.63	3599.0	216.90	41.83	2.202	0.36	1.00	1.30	120.0	40000.0	3000.0	65.0	1.0	20.0	1.50	000222
284.0	55.62	3599.0	199.00	37.76	2.293	0.36	1.00	1.30	120.0	80000.0	3000.0	65.0	1.0	20.0	1.50	000111
285.0	-11.75	4546.0	172.20	103.36	2.194	0.20	1.15	0.70	80.0	40000.0	3000.0	65.0	1.0	20.0	1.50	000111
286.0	117.30	4546.0	160.20	83.41	2.312	0.20	1.15	0.70	80.0	80000.0	3000.0	65.0	1.0	20.0	1.50	000322
287.0	0.84	7225.0	204.00	100.80	1.720	0.20	1.15	0.70	120.0	40000.0	3000.0	65.0	1.0	20.0	1.50	000222
288.0	172.40	7225.0	185.90	79.81	1.818	0.20	1.15	0.70	120.0	80000.0	3000.0	65.0	1.0	20.0	1.50	000111
289.0	-93.15	2401.0	186.10	38.23	2.783	0.20	1.15	1.30	80.0	40000.0	3000.0	65.0	1.0	20.0	1.50	000322
290.0	2.74	2401.0	174.30	34.72	2.896	0.20	1.15	1.30	80.0	80000.0	3000.0	65.0	1.0	20.0	1.50	000111
291.0	-96.25	3504.0	222.10	37.76	2.158	0.20	1.15	1.30	120.0	40000.0	3000.0	65.0	1.0	20.0	1.50	000111
292.0	20.96	3504.0	204.50	34.41	2.246	0.20	1.15	1.30	120.0	80000.0	3000.0	65.0	1.0	20.0	1.50	000222
293.0	8.25	4729.0	169.20	115.81	2.287	1.80	1.00	0.70	80.0	40000.0	3000.0	65.0	1.0	20.0	1.50	000111
294.0	101.10	4729.0	157.10	90.76	2.403	1.80	1.00	0.70	80.0	80000.0	3000.0	65.0	1.0	20.0	1.50	000232
295.0	19.75	7584.0	200.40	110.27	1.783	1.80	1.00	0.70	120.0	40000.0	3000.0	65.0	1.0	20.0	1.50	000332
296.0	141.80	7584.0	182.10	89.28	1.870	1.80	1.00	0.70	120.0	80000.0	3000.0	65.0	1.0	20.0	1.50	000111
297.0	-42.80	2476.0	181.50	40.21	2.884	1.80	1.00	1.30	80.0	40000.0	3000.0	65.0	1.0	20.0	1.50	000232
298.0	42.23	2476.0	169.30	36.43	2.998	1.80	1.00	1.30	80.0	80000.0	3000.0	65.0	1.0	20.0	1.50	000111
299.0	-44.06	3652.0	216.30	39.53	2.240	1.80	1.00	1.30	120.0	40000.0	3000.0	65.0	1.0	20.0	1.50	000111
300.0	64.97	3652.0	198.10	36.04	2.331	1.80	1.00	1.30	120.0	80000.0	3000.0	65.0	1.0	20.0	1.50	000332
301.0	8.07	4661.0	170.60	86.44	2.221	1.80	1.15	0.70	80.0	40000.0	3000.0	65.0	1.0	20.0	1.50	000232
302.0	124.30	4661.0	158.50	72.76	2.338	1.80	1.15	0.70	80.0	80000.0	3000.0	65.0	1.0	20.0	1.50	000111

N	RANGE DASH(NM)	TO DIST (FT)	VEL (FT/SEC)	TIME (SEC)	G-LOAD	BPR	TR	T/W	W/S	GW (LBS)	T4 (DEGREES)	SWEEP (DEGREES)	AB	OPR	AR	ID
303.0	24.28	7406.0	202.00	85.21	1.737	1.80	1.15	0.70	120.0	40000.0	3000.0	65.0	1.0	20.0	1.50	000111
304.0	189.40	7406.0	183.80	70.24	1.834	1.80	1.15	0.70	120.0	80000.0	3000.0	65.0	1.0	20.0	1.50	000332
305.0	-69.85	2449.0	183.80	34.08	2.808	1.80	1.15	1.30	80.0	40000.0	3000.0	65.0	1.0	20.0	1.50	000111
306.0	44.77	2449.0	171.60	31.36	2.920	1.80	1.15	1.30	80.0	80000.0	3000.0	65.0	1.0	20.0	1.50	000232
307.0	-76.76	3579.0	219.20	33.83	2.173	1.80	1.15	1.30	120.0	40000.0	3000.0	65.0	1.0	20.0	1.50	000332
308.0	69.15	3579.0	201.20	31.21	2.261	1.80	1.15	1.30	120.0	80000.0	3000.0	65.0	1.0	20.0	1.50	000111
309.0	109.10	2590.0	143.50	46.98	2.429	1.00	1.07	1.00	100.0	60000.0	3000.0	50.0	0.0	20.0	1.50	000300
310.0	98.39	2611.0	145.50	45.86	2.420	1.00	1.07	1.00	100.0	60000.0	2400.0	50.0	0.0	25.0	1.50	000030
311.0	97.28	2571.0	144.90	49.14	2.417	0.20	1.07	1.00	100.0	60000.0	2700.0	50.0	0.0	25.0	1.50	000030
312.0	108.70	2648.0	142.60	54.68	2.471	1.00	1.00	1.00	100.0	60000.0	2700.0	50.0	0.0	25.0	1.50	000030
313.0	131.40	3728.0	137.90	81.14	2.096	1.00	1.07	0.70	100.0	60000.0	2700.0	50.0	0.0	25.0	1.50	000030
314.0	77.78	2593.0	145.00	49.18	2.402	1.00	1.07	1.00	100.0	60000.0	2700.0	50.0	1.0	25.0	1.50	000030
315.0	100.70	2030.0	123.60	49.18	2.389	1.00	1.07	1.00	100.0	60000.0	2700.0	35.0	0.0	25.0	1.50	000030
316.0	87.05	2145.0	131.50	47.81	2.778	1.00	1.07	1.00	80.0	60000.0	2700.0	50.0	0.0	25.0	1.50	000030
317.0	17.58	2596.0	152.80	50.58	2.354	1.00	1.07	1.00	100.0	40000.0	2700.0	50.0	0.0	25.0	1.50	000030
318.0	112.90	2596.0	143.70	46.62	2.426	1.00	1.07	1.00	100.0	60000.0	2700.0	50.0	0.0	25.0	1.50	000033
319.0	169.70	2596.0	139.20	45.07	2.463	1.00	1.07	1.00	100.0	80000.0	2700.0	50.0	0.0	25.0	1.50	000030
320.0	129.80	3079.0	155.20	46.30	2.157	1.00	1.07	1.00	120.0	60000.0	2700.0	50.0	0.0	25.0	1.50	000030
321.0	113.70	3896.0	180.70	45.50	2.306	1.00	1.07	1.00	100.0	60000.0	2700.0	65.0	0.0	25.0	1.50	000030
322.0	111.20	2600.0	143.50	46.37	2.428	1.00	1.07	1.00	100.0	60000.0	2700.0	50.0	-1.0	25.0	1.50	000030
323.0	78.17	2064.0	149.10	33.03	2.654	1.00	1.07	1.30	100.0	60000.0	2700.0	50.0	0.0	25.0	1.50	000030
324.0	93.43	2612.0	146.50	46.73	2.408	1.00	1.15	1.00	100.0	60000.0	2700.0	50.0	0.0	25.0	1.50	000030
325.0	93.18	2623.0	144.00	45.72	2.416	1.80	1.07	1.00	100.0	60000.0	2700.0	50.0	0.0	25.0	1.50	000030
326.0	115.30	2591.0	143.10	47.05	2.428	1.00	1.07	1.00	100.0	60000.0	3000.0	50.0	0.0	25.0	1.50	000030
327.0	107.70	2293.0	106.40	125.24	2.338	0.20	1.00	0.70	80.0	80000.0	2400.0	35.0	1.0	30.0	1.50	000033
328.0	24.84	3367.0	138.50	151.20	1.760	0.20	1.00	0.70	120.0	40000.0	2400.0	35.0	1.0	30.0	1.50	000033
329.0	-36.40	1474.0	125.10	46.94	2.941	0.20	1.00	1.30	80.0	40000.0	2400.0	35.0	1.0	30.0	1.50	000033
330.0	101.30	1916.0	136.20	39.82	2.423	0.20	1.00	1.30	120.0	80000.0	2400.0	35.0	1.0	30.0	1.50	000033
331.0	9.82	2278.0	118.40	126.86	2.155	0.20	1.15	0.70	80.0	40000.0	2400.0	35.0	1.0	30.0	1.50	000033
332.0	182.20	3324.0	127.60	86.47	1.830	0.20	1.15	0.70	120.0	80000.0	2400.0	35.0	1.0	30.0	1.50	000033
333.0	38.63	1467.0	119.60	36.18	3.010	0.20	1.15	1.30	80.0	80000.0	2400.0	35.0	1.0	30.0	1.50	000033
334.0	-82.84	1898.0	155.00	38.41	2.274	0.20	1.15	1.30	120.0	40000.0	2400.0	35.0	1.0	30.0	1.50	000033
335.0	13.44	2338.0	116.30	150.01	2.257	1.80	1.00	0.70	80.0	40000.0	2400.0	35.0	1.0	30.0	1.50	000023
336.0	125.00	3440.0	124.50	99.68	1.894	1.80	1.00	0.70	120.0	80000.0	2400.0	35.0	1.0	[illegible]	1.50	000023
337.0	53.97	1492.0	115.40	38.27	3.135	1.80	1.00	1.30	80.0	80000.0	2400.0	35.0	1.0	30.0	1.50	000023
338.0	-22.86	1946.0	150.40	40.25	2.361	1.80	1.00	1.30	120.0	40000.0	2400.0	35.0	1.0	30.0	1.50	000023
339.0	97.74	2346.0	109.10	82.69	2.315	1.60	1.15	0.70	80.0	80000.0	2400.0	35.0	1.0	30.0	1.50	000023
340.0	18.26	3435.0	141.90	90.83	1.741	1.60	1.15	0.70	120.0	40000.0	2400.0	35.0	1.0	30.0	1.50	000023
341.0	-52.76	1495.0	129.70	35.16	2.907	1.60	1.15	1.30	80.0	40000.0	2400.0	35.0	1.0	30.0	1.50	000023
342.0	19.96	1944.0	142.40	31.62	2.383	1.60	1.15	1.30	120.0	80000.0	2400.0	35.0	1.0	30.0	1.50	000023
343.0	11.25	4669.0	169.70	126.79	2.240	0.20	1.00	0.70	80.0	40000.0	2400.0	65.0	1.0	30.0	1.50	000022
344.0	203.40	7496.0	182.40	92.63	1.843	0.20	1.00	0.70	120.0	80000.0	2400.0	65.0	1.0	30.0	1.50	000022
345.0	57.78	2452.0	170.10	38.20	2.941	0.20	1.00	1.30	80.0	80000.0	2400.0	65.0	1.0	30.0	1.50	000022
346.0	-64.58	3616.0	216.60	41.80	2.194	0.20	1.00	1.30	120.0	40000.0	2400.0	65.0	1.0	30.0	1.50	000022
347.0	134.20	4583.0	161.10	79.81	2.310	0.20	1.15	0.70	80.0	80000.0	2400.0	65.0	1.0	30.0	1.50	000022
348.0	16.07	7288.0	204.80	95.72	1.719	0.20	1.15	0.70	120.0	40000.0	2400.0	65.0	1.0	30.0	1.50	000022
349.0	-104.50	2416.0	187.70	36.97	2.774	0.20	1.15	1.30	80.0	40000.0	2400.0	65.0	1.0	30.0	1.50	000022
350.0	39.48	3530.0	206.50	33.47	2.238	0.20	1.15	1.30	120.0	80000.0	2400.0	65.0	1.0	30.0	1.50	000022
351.0	105.40	4774.0	157.60	86.69	2.399	1.80	1.00	0.70	80.0	80000.0	2400.0	65.0	1.0	30.0	1.50	000032
352.0	28.44	7659.0	200.90	103.68	1.780	1.80	1.00	0.70	120.0	40000.0	2400.0	65.0	1.0	30.0	1.50	000032

N	RANGE DASH(NM)	TO DIST (FT)	VEL (FT/SEC)	TIME (SEC)	G-LOAD	BPR	TR	T/W	W/S	GW (LBS)	T4 (DEGREES)	SWEEP (DEGREES)	AB	OPR	AR	ID
353.0	-36.96	2495.0	182.40	38.74	2.875	1.80	1.00	1.30	80.0	40000.0	2400.0	65.0	1.0	30.0	1.50	000032
354.0	69.04	3683.0	195.40	35.07	2.320	1.80	1.00	1.30	120.0	80000.0	2400.0	65.0	1.0	30.0	1.50	000032
355.0	0.31	4739.0	173.40	81.47	2.221	1.60	1.15	0.70	80.0	40000.0	2400.0	65.0	1.0	30.0	1.50	000032
356.0	152.00	7526.0	187.70	69.84	1.819	1.60	1.15	0.70	120.0	80000.0	2400.0	65.0	1.0	30.0	1.50	000032
357.0	16.07	2481.0	176.60	30.47	2.903	1.60	1.15	1.30	80.0	80000.0	2400.0	65.0	1.0	30.0	1.50	000032
358.0	-93.26	3628.0	225.40	32.76	2.161	1.60	1.15	1.30	120.0	40000.0	2400.0	65.0	1.0	30.0	1.50	000032
359.0	0.04	2056.0	117.20	124.13	2.363	0.20	1.00	0.80	80.0	40000.0	2400.0	35.0	-1.0	30.0	1.50	000022
360.0	155.00	3381.0	123.60	110.92	1.868	0.20	1.00	0.70	120.0	80000.0	2400.0	35.0	-1.0	30.0	1.50	000022
361.0	79.58	1477.0	114.40	41.08	3.096	0.20	1.00	1.30	80.0	80000.0	2400.0	35.0	-1.0	30.0	1.50	000022
362.0	-30.72	1921.0	148.60	43.60	2.338	0.20	1.00	1.30	120.0	40000.0	2400.0	35.0	-1.0	30.0	1.50	000022
363.0	125.60	2281.0	108.20	90.11	2.320	0.20	1.15	0.70	80.0	80000.0	2400.0	35.0	-1.0	30.0	1.50	000022
364.0	31.14	3328.0	140.60	101.27	1.747	0.20	1.15	0.70	120.0	40000.0	2400.0	35.0	-1.0	30.0	1.50	000022
365.0	-63.27	1468.0	128.00	38.66	2.907	0.20	1.15	1.30	80.0	40000.0	2400.0	35.0	-1.0	30.0	1.50	000022
366.0	74.44	1899.0	140.10	33.27	2.405	0.20	1.15	1.30	120.0	80000.0	2400.0	35.0	-1.0	30.0	1.50	000022
367.0	104.60	2345.0	105.80	101.92	2.404	1.80	1.00	0.70	80.0	80000.0	2400.0	35.0	-1.0	30.0	1.50	000032
368.0	37.40	3451.0	138.00	113.15	1.813	1.80	1.00	0.70	120.0	40000.0	2400.0	35.0	-1.0	30.0	1.50	000032
369.0	-15.65	1495.0	124.50	41.11	3.015	1.80	1.00	1.30	80.0	40000.0	2400.0	35.0	-1.0	30.0	1.50	000032
370.0	89.17	1950.0	135.30	35.86	2.470	1.80	1.00	1.30	120.0	80000.0	2400.0	35.0	-1.0	30.0	1.50	000032
371.0	10.84	2358.0	118.80	98.10	2.135	1.60	1.15	0.70	80.0	40000.0	2400.0	35.0	-1.0	30.0	1.50	000032
372.0	123.30	3455.0	127.90	74.12	1.811	1.60	1.15	0.70	120.0	80000.0	2400.0	35.0	-1.0	30.0	1.50	000032
373.0	39.03	1500.0	119.80	32.17	2.975	1.60	1.15	1.30	80.0	80000.0	2400.0	35.0	-1.0	30.0	1.50	000032
374.0	-69.69	1952.0	155.90	33.96	2.244	1.60	1.15	1.30	120.0	40000.0	2400.0	35.0	-1.0	30.0	1.50	000032
375.0	133.80	4694.0	156.80	94.82	2.366	0.20	1.00	0.70	80.0	80000.0	2400.0	65.0	-1.0	30.0	1.50	000033
376.0	27.71	7548.0	199.70	124.56	1.759	0.20	1.00	0.70	120.0	40000.0	2400.0	65.0	-1.0	30.0	1.50	000033
377.0	-53.29	2462.0	180.60	42.01	2.845	0.20	1.00	1.30	80.0	40000.0	2400.0	65.0	-1.0	30.0	1.50	000033
378.0	110.30	3637.0	196.90	37.08	2.303	0.20	1.00	1.30	120.0	80000.0	2400.0	65.0	-1.0	30.0	1.50	000033
379.0	8.56	4587.0	172.00	90.43	2.224	0.20	1.15	0.70	80.0	40000.0	2400.0	65.0	-1.0	30.0	1.50	000033
380.0	240.20	7291.0	185.70	73.84	1.830	0.20	1.15	0.70	120.0	80000.0	2400.0	65.0	-1.0	30.0	1.50	000033
381.0	29.38	2418.0	174.20	32.32	2.918	0.20	1.15	1.30	80.0	80000.0	2400.0	65.0	-1.0	30.0	1.50	000033
382.0	-88.02	3531.0	221.70	34.99	2.175	0.20	1.15	1.30	120.0	40000.0	2400.0	65.0	-1.0	30.0	1.50	000033
383.0	20.69	4788.0	169.10	100.40	2.302	1.80	1.00	0.70	80.0	40000.0	2400.0	65.0	-1.0	30.0	1.50	000023
384.0	175.00	7679.0	181.70	80.06	1.881	1.80	1.00	0.70	120.0	80000.0	2400.0	65.0	-1.0	30.0	1.50	000023
385.0	62.07	2501.0	169.10	34.49	2.999	1.80	1.00	1.30	80.0	80000.0	2400.0	65.0	-1.0	30.0	1.50	000023
386.0	-30.28	3691.0	215.90	37.26	2.241	1.80	1.00	1.30	120.0	40000.0	2400.0	65.0	-1.0	30.0	1.50	000023
387.0	116.90	4769.0	161.30	69.05	2.290	1.60	1.15	0.70	80.0	80000.0	2400.0	65.0	-1.0	30.0	1.50	000023
388.0	17.31	7575.0	205.60	80.35	1.703	1.60	1.15	0.70	120.0	40000.0	2400.0	65.0	-1.0	30.0	1.50	000023
389.0	-90.47	2493.0	188.60	32.76	2.745	1.60	1.15	1.30	80.0	40000.0	2400.0	65.0	-1.0	30.0	1.50	000023
390.0	46.26	3648.0	207.50	30.30	2.208	1.60	1.15	1.30	120.0	80000.0	2400.0	65.0	-1.0	30.0	1.50	000023
391.0	115.20	2597.0	143.60	46.58	2.427	1.00	1.07	1.00	100.0	60000.0	2700.0	50.0	0.0	30.0	1.50	000030
392.0	1.63	2048.0	117.90	129.13	2.348	0.48	1.00	0.80	80.0	40000.0	3000.0	35.0	1.0	30.0	1.50	000022
393.0	152.00	3360.0	123.30	110.70	1.867	0.48	1.00	0.70	120.0	80000.0	3000.0	35.0	1.0	30.0	1.50	000022
394.0	66.26	1472.0	113.90	42.05	3.087	0.48	1.00	1.30	80.0	80000.0	3000.0	35.0	1.0	30.0	1.50	000022
395.0	-36.64	1913.0	148.30	44.60	2.332	0.48	1.00	1.30	120.0	40000.0	3000.0	35.0	1.0	30.0	1.50	000022
396.0	125.50	2264.0	107.80	98.10	2.305	0.20	1.15	0.70	80.0	80000.0	3000.0	35.0	1.0	30.0	1.50	000022
397.0	23.95	3300.0	140.20	111.28	1.735	0.20	1.15	0.70	120.0	40000.0	3000.0	35.0	1.0	30.0	1.50	000022
398.0	-61.39	1462.0	127.30	40.82	2.896	0.20	1.15	1.30	80.0	40000.0	3000.0	35.0	1.0	30.0	1.50	000022
399.0	55.99	1888.0	139.20	35.51	2.388	0.20	1.15	1.30	120.0	80000.0	3000.0	35.0	1.0	30.0	1.50	000022
400.0	89.15	2319.0	105.60	124.99	2.382	1.80	1.00	0.70	80.0	80000.0	3000.0	35.0	1.0	30.0	1.50	000032
401.0	25.08	3409.0	137.70	141.52	1.795	1.80	1.00	0.70	120.0	40000.0	3000.0	35.0	1.0	30.0	1.50	000032
402.0	-17.54	1484.0	124.00	45.07	3.009	1.80	1.00	1.30	80.0	40000.0	3000.0	35.0	1.0	30.0	1.50	000032
403.0	77.93	1933.0	134.70	38.70	2.468	1.80	1.00	1.30	120.0	80000.0	3000.0	35.0	1.0	30.0	1.50	000032

N	RANGE DASH(NM)	TO DIST (FT)	VEL (FT/SEC)	TIME (SEC)	G-LOAD	BPR	TR	T/W	W/S	GW (LBS)	T4 (DEGREES)	SWEEP (DEGREES)	AB	OPR	AR	ID
404.0	19.20	2312.0	116.70	108.00	2.188	1.80	1.15	0.70	80.0	40000.0	3000.0	35.0	1.0	30.0	1.50	000032
405.0	147.50	3378.0	125.10	78.34	1.852	1.80	1.15	0.70	120.0	80000.0	3000.0	35.0	1.0	30.0	1.50	000032
406.0	62.40	1481.0	116.10	33.51	3.052	1.80	1.15	1.30	80.0	80000.0	3000.0	35.0	1.0	30.0	1.50	000032
407.0	-42.58	1920.0	151.30	35.34	2.301	1.80	1.15	1.30	120.0	40000.0	3000.0	35.0	1.0	30.0	1.50	000032
408.0	127.90	4657.0	156.50	95.11	2.366	0.48	1.00	0.70	80.0	80000.0	3000.0	65.0	1.0	30.0	1.50	000033
409.0	26.23	7474.0	199.50	121.03	1.759	0.48	1.00	0.70	120.0	40000.0	3000.0	65.0	1.0	30.0	1.50	000033
410.0	-54.93	2447.0	180.20	42.77	2.840	0.48	1.00	1.30	80.0	40000.0	3000.0	65.0	1.0	30.0	1.50	000033
411.0	88.44	3607.0	196.40	37.94	2.294	0.48	1.00	1.30	120.0	80000.0	3000.0	65.0	1.0	30.0	1.50	000033
412.0	-1.67	4548.0	171.60	101.70	2.199	0.20	1.15	0.70	80.0	40000.0	3000.0	65.0	1.0	30.0	1.50	000033
413.0	203.80	7229.0	185.00	78.80	1.821	0.20	1.15	0.70	120.0	80000.0	3000.0	65.0	1.0	30.0	1.50	000033
414.0	18.60	2402.0	173.30	34.26	2.903	0.20	1.15	1.30	80.0	80000.0	3000.0	65.0	1.0	30.0	1.50	000033
415.0	-87.67	3506.0	220.70	37.26	2.164	0.20	1.15	1.30	120.0	40000.0	3000.0	65.0	1.0	30.0	1.50	000033
416.0	12.74	4729.0	168.70	121.03	2.284	1.80	1.00	0.70	80.0	40000.0	3000.0	65.0	1.0	30.0	1.50	000023
417.0	147.00	7590.0	181.30	92.27	1.867	1.80	1.00	0.70	120.0	80000.0	3000.0	65.0	1.0	30.0	1.50	000023
418.0	52.34	2477.0	168.40	37.12	2.995	1.80	1.00	1.30	80.0	80000.0	3000.0	65.0	1.0	30.0	1.50	000023
419.0	-33.19	3654.0	215.00	40.32	2.238	1.80	1.00	1.30	120.0	40000.0	3000.0	65.0	1.0	30.0	1.50	000023
420.0	129.60	4658.0	158.30	72.94	2.339	1.80	1.15	0.70	80.0	80000.0	3000.0	65.0	1.0	30.0	1.50	000023
421.0	30.57	7400.0	201.70	85.39	1.738	1.80	1.15	0.70	120.0	40000.0	3000.0	65.0	1.0	30.0	1.50	000023
422.0	-62.33	2447.0	183.40	34.12	2.809	1.80	1.15	1.30	80.0	40000.0	3000.0	65.0	1.0	30.0	1.50	000023
423.0	82.94	3576.0	200.70	31.28	2.261	1.80	1.15	1.30	120.0	80000.0	3000.0	65.0	1.0	30.0	1.50	000023
424.0	96.14	2296.0	104.60	129.10	2.362	0.48	1.00	0.70	80.0	80000.0	3000.0	35.0	-1.0	30.0	1.50	000033
425.0	-8.89	3373.0	136.50	163.40	1.780	0.48	1.00	0.70	120.0	40000.0	3000.0	35.0	-1.0	30.0	1.50	000033
426.0	-17.08	1475.0	122.10	46.22	2.988	0.48	1.00	1.30	80.0	40000.0	3000.0	35.0	-1.0	30.0	1.50	000033
427.0	125.00	1918.0	132.00	38.99	2.463	0.48	1.00	1.30	120.0	80000.0	3000.0	35.0	-1.0	30.0	1.50	000033
428.0	15.00	2264.0	116.90	123.05	2.190	0.20	1.15	0.70	80.0	40000.0	3000.0	35.0	-1.0	30.0	1.50	000033
429.0	201.30	3299.0	125.30	86.69	1.849	0.20	1.15	0.70	120.0	80000.0	3000.0	35.0	-1.0	30.0	1.50	000033
430.0	53.64	1462.0	116.50	35.41	3.060	0.20	1.15	1.30	80.0	80000.0	3000.0	35.0	-1.0	30.0	1.50	000033
431.0	-56.71	1888.0	151.20	37.55	2.312	0.20	1.15	1.30	120.0	40000.0	3000.0	35.0	-1.0	30.0	1.50	000033
432.0	6.55	2322.0	114.80	160.20	2.284	1.80	1.00	0.70	80.0	40000.0	3000.0	35.0	-1.0	30.0	1.50	000023
433.0	154.30	3412.0	122.50	99.83	1.924	1.80	1.00	0.70	120.0	80000.0	3000.0	35.0	-1.0	30.0	1.50	000023
434.0	81.67	1485.0	112.80	38.59	3.176	1.80	1.00	1.30	80.0	80000.0	3000.0	35.0	-1.0	30.0	1.50	000023
435.0	-10.99	1934.0	147.10	41.47	2.385	1.80	1.00	1.30	120.0	40000.0	3000.0	35.0	-1.0	30.0	1.50	000023
436.0	129.50	2319.0	106.60	81.61	2.333	1.80	1.15	0.70	80.0	80000.0	3000.0	35.0	-1.0	30.0	1.50	000023
437.0	42.61	3391.0	139.00	89.96	1.754	1.80	1.15	0.70	120.0	40000.0	3000.0	35.0	-1.0	30.0	1.50	000023
438.0	-32.92	1484.0	125.70	35.70	2.922	1.80	1.15	1.30	80.0	40000.0	3000.0	35.0	-1.0	30.0	1.50	000023
439.0	97.97	1926.0	136.90	31.82	2.401	1.80	1.15	1.30	120.0	80000.0	3000.0	35.0	-1.0	30.0	1.50	000023
440.0	8.05	4680.0	167.70	133.27	2.263	0.48	1.00	0.70	80.0	40000.0	3000.0	65.0	-1.0	30.0	1.50	000022
441.0	194.80	7520.0	179.20	93.92	1.860	0.48	1.00	0.70	120.0	80000.0	3000.0	65.0	-1.0	30.0	1.50	000022
442.0	84.19	2456.0	165.70	37.62	2.984	0.48	1.00	1.30	80.0	80000.0	3000.0	65.0	-1.0	30.0	1.50	000022
443.0	-31.98	3626.0	211.30	41.00	2.229	0.48	1.00	1.30	120.0	40000.0	3000.0	65.0	-1.0	30.0	1.50	000022
444.0	156.20	4545.0	158.60	77.44	2.344	0.20	1.15	0.70	80.0	80000.0	3000.0	65.0	-1.0	30.0	1.50	000022
445.0	29.92	7222.0	201.90	93.02	1.743	0.20	1.15	0.70	120.0	40000.0	3000.0	65.0	-1.0	30.0	1.50	000022
446.0	-75.61	2401.0	183.50	36.32	2.816	0.20	1.15	1.30	80.0	40000.0	3000.0	65.0	-1.0	30.0	1.50	000022
447.0	62.64	3503.0	200.70	32.67	2.276	0.20	1.15	1.30	120.0	80000.0	3000.0	65.0	-1.0	30.0	1.50	000022
448.0	133.90	4732.0	155.60	87.12	2.426	1.80	1.00	0.70	80.0	80000.0	3000.0	65.0	-1.0	30.0	1.50	000032
449.0	40.38	7589.0	198.30	106.31	1.800	1.80	1.00	0.70	120.0	40000.0	3000.0	65.0	-1.0	30.0	1.50	000032
450.0	-27.71	2478.0	178.80	39.92	2.901	1.80	1.00	1.30	80.0	40000.0	3000.0	65.0	-1.0	30.0	1.50	000032
451.0	123.80	3654.0	194.40	35.09	2.354	1.80	1.00	1.30	120.0	80000.0	3000.0	65.0	-1.0	30.0	1.50	000032
452.0	16.51	4677.0	170.00	83.95	2.222	1.80	1.15	0.70	80.0	40000.0	3000.0	65.0	-1.0	30.0	1.50	000032
453.0	214.70	7431.0	183.10	68.65	1.835	1.80	1.15	0.70	120.0	80000.0	3000.0	65.0	-1.0	30.0	1.50	000032
454.0	62.94	2455.0	170.60	30.75	2.922	1.80	1.15	1.30	80.0	80000.0	3000.0	65.0	-1.0	30.0	1.50	000032

N	RANGE DASH(NM)	TO DIST (FT)	VEL (FT/SEC)	TIME (SEC)	G-LOAD	BPR	TR	T/W	W/S	GW (LBS)	T4 (DEGREES)	SWEEP (DEGREES)	AB	OPR	AR	ID
455.0	-66.56	3589.0	218.00	33.14	2.175	1.80	1.15	1.30	120.0	40000.0	3000.0	65.0	-1.0	30.0	1.50	000003
456.0	112.00	2293.0	109.30	117.68	3.136	0.20	1.00	0.70	80.0	80000.0	2400.0	35.0	1.0	20.0	3.50	000003
457.0	39.57	3364.0	140.60	131.65	2.343	0.20	1.00	0.70	120.0	40000.0	2400.0	35.0	1.0	20.0	3.50	000003
458.0	-30.68	1473.0	127.50	45.68	3.855	0.20	1.00	1.30	80.0	40000.0	2400.0	35.0	1.0	20.0	3.50	000003
459.0	102.40	1915.0	139.40	38.27	3.283	0.20	1.00	1.30	120.0	80000.0	2400.0	35.0	1.0	20.0	3.50	000003
460.0	17.50	2274.0	120.20	125.64	2.927	0.20	1.15	0.70	80.0	40000.0	2400.0	35.0	1.0	20.0	3.50	000003
461.0	180.10	3317.0	129.80	85.21	2.419	0.20	1.15	0.70	120.0	80000.0	2400.0	35.0	1.0	20.0	3.50	000003
462.0	43.29	1466.0	121.70	36.32	3.947	0.20	1.15	1.30	80.0	80000.0	2400.0	35.0	1.0	20.0	3.50	000003
463.0	-51.31	1895.0	155.80	37.76	3.067	0.20	1.15	1.30	120.0	40000.0	2400.0	35.0	1.0	20.0	3.50	000003
464.0	19.12	2336.0	118.00	144.58	3.032	1.80	1.00	0.70	80.0	40000.0	2400.0	35.0	1.0	20.0	3.50	000003
465.0	134.60	3435.0	126.80	92.38	2.524	1.80	1.00	0.70	120.0	80000.0	2400.0	35.0	1.0	20.0	3.50	000003
466.0	57.85	1491.0	117.60	37.76	4.132	1.80	1.00	1.30	80.0	80000.0	2400.0	35.0	1.0	20.0	3.50	000003
467.0	-8.62	1944.0	151.60	38.99	3.217	1.80	1.00	1.30	120.0	40000.0	2400.0	35.0	1.0	20.0	3.50	000003
468.0	106.60	2339.0	110.60	79.78	3.116	1.80	1.15	0.70	80.0	80000.0	2400.0	35.0	1.0	20.0	3.50	000003
469.0	41.21	3422.0	142.50	83.52	2.326	1.80	1.15	0.70	120.0	40000.0	2400.0	35.0	1.0	20.0	3.50	000003
470.0	-31.71	1492.0	129.90	34.64	3.832	1.80	1.15	1.30	80.0	40000.0	2400.0	35.0	1.0	20.0	3.50	000003
471.0	80.25	1938.0	142.50	30.61	3.255	1.80	1.15	1.30	120.0	80000.0	2400.0	35.0	1.0	20.0	3.50	000003
472.0	2.99	4578.0	177.70	88.74	2.618	0.20	1.15	0.70	80.0	40000.0	2400.0	65.0	-1.0	20.0	3.50	000003
473.0	228.00	7279.0	192.70	69.95	2.082	0.20	1.15	0.70	120.0	80000.0	2400.0	65.0	-1.0	20.0	3.50	000003
474.0	12.16	2414.0	181.00	32.71	3.258	0.20	1.15	1.30	80.0	80000.0	2400.0	65.0	-1.0	20.0	3.50	000003
475.0	-74.59	3526.0	225.60	34.78	2.461	0.20	1.15	1.30	120.0	40000.0	2400.0	65.0	-1.0	20.0	3.50	000003
476.0	116.20	4697.0	165.70	90.22	2.758	0.20	1.00	0.70	80.0	80000.0	2400.0	65.0	-1.0	20.0	3.50	000003
477.0	32.97	7554.0	205.90	111.71	2.006	0.20	1.00	0.70	120.0	40000.0	2400.0	65.0	-1.0	20.0	3.50	000003
478.0	-65.87	2463.0	187.40	41.36	3.184	0.20	1.00	1.30	80.0	40000.0	2400.0	65.0	-1.0	20.0	3.50	000003
479.0	90.54	3639.0	205.40	35.99	2.610	0.20	1.00	1.30	120.0	80000.0	2400.0	65.0	-1.0	20.0	3.50	000003
480.0	110.50	4753.0	168.30	66.56	2.714	1.80	1.15	0.70	80.0	80000.0	2400.0	65.0	-1.0	20.0	3.50	000003
481.0	31.65	7551.0	209.60	74.16	1.969	1.80	1.15	0.70	120.0	40000.0	2400.0	65.0	-1.0	20.0	3.50	000003
482.0	-85.34	2486.0	192.20	32.32	3.118	1.80	1.15	1.30	80.0	40000.0	2400.0	65.0	-1.0	20.0	3.50	000003
483.0	63.61	3638.0	211.80	29.33	2.540	1.80	1.15	1.30	120.0	80000.0	2400.0	65.0	-1.0	20.0	3.50	000003
484.0	13.44	4780.0	175.50	99.83	2.676	1.80	1.00	0.70	80.0	40000.0	2400.0	65.0	-1.0	20.0	3.50	000003
485.0	185.60	7662.0	189.70	74.56	2.135	1.80	1.00	0.70	120.0	80000.0	2400.0	65.0	-1.0	20.0	3.50	000003
486.0	47.94	2497.0	176.90	34.01	3.354	1.80	1.00	1.30	80.0	80000.0	2400.0	65.0	-1.0	20.0	3.50	000003
487.0	-29.03	3684.0	221.10	36.11	2.548	1.80	1.00	1.30	120.0	40000.0	2400.0	65.0	-1.0	20.0	3.50	000003
488.0	103.70	4648.0	165.60	94.28	2.750	0.36	1.00	0.70	80.0	80000.0	3000.0	65.0	1.0	20.0	3.50	000003
489.0	28.96	7455.0	205.90	110.12	2.006	0.36	1.00	0.70	120.0	40000.0	3000.0	65.0	1.0	20.0	3.50	000003
490.0	-68.32	2443.0	187.20	42.23	3.180	0.36	1.00	1.30	80.0	40000.0	3000.0	65.0	1.0	20.0	3.50	000003
491.0	66.65	3599.0	205.40	36.90	2.602	0.36	1.00	1.30	120.0	80000.0	3000.0	65.0	1.0	20.0	3.50	000003
492.0	-8.81	4546.0	177.80	99.43	2.596	0.20	1.15	0.70	80.0	40000.0	3000.0	65.0	1.0	20.0	3.50	000003
493.0	182.20	7225.0	192.90	74.74	2.071	0.20	1.15	0.70	120.0	80000.0	3000.0	65.0	1.0	20.0	3.50	000003
494.0	-0.95	2401.0	181.20	34.44	3.243	0.20	1.15	1.30	80.0	80000.0	3000.0	65.0	1.0	20.0	3.50	000003
495.0	-78.47	3504.0	226.10	36.72	2.447	0.20	1.15	1.30	120.0	40000.0	3000.0	65.0	1.0	20.0	3.50	000003
496.0	8.10	4729.0	175.10	111.89	2.674	1.80	1.00	0.70	80.0	40000.0	3000.0	65.0	1.0	20.0	3.50	000003
497.0	149.60	7584.0	189.50	83.59	2.124	1.80	1.00	0.70	120.0	80000.0	3000.0	65.0	1.0	20.0	3.50	000003
498.0	34.88	2476.0	176.60	36.18	3.352	1.80	1.00	1.30	80.0	80000.0	3000.0	65.0	1.0	20.0	3.50	000003
499.0	-32.47	3652.0	220.70	38.56	2.547	1.80	1.00	1.30	120.0	40000.0	3000.0	65.0	1.0	20.0	3.50	000003
500.0	113.70	4661.0	166.50	70.42	2.736	1.80	1.15	0.70	80.0	80000.0	3000.0	65.0	1.0	20.0	3.50	000003
501.0	36.27	7406.0	207.20	79.09	1.987	1.80	1.15	0.70	120.0	40000.0	3000.0	65.0	1.0	20.0	3.50	000003
502.0	-68.56	2449.0	189.10	33.77	3.154	1.80	1.15	1.30	80.0	40000.0	3000.0	65.0	1.0	20.0	3.50	000003
503.0	74.93	3579.0	207.80	30.43	2.574	1.80	1.15	1.30	120.0	80000.0	3000.0	65.0	1.0	20.0	3.50	000003
504.0	103.40	2296.0	107.60	124.92	3.158	0.36	1.00	0.70	80.0	80000.0	3000.0	35.0	-1.0	20.0	3.50	000003

N	RANGE DASH(NM)	TO DIST (FT)	VEL (FT/SEC)	TIME (SEC)	G-LOAD	BPR	TR	T/W	W/S	GW (LBS)	T4 (DEGREES)	SWEEP (DEGREES)	AB	OPR	AR	ID
505.0	28.53	3374.0	138.70	149.65	2.363	0.36	1.00	0.70	120.0	40000.0	3000.0	35.0	-1.0	20.0	3.50	000003
506.0	-12.71	1475.0	124.70	45.72	3.910	0.36	1.00	1.30	80.0	40000.0	3000.0	35.0	-1.0	20.0	3.50	000003
507.0	123.00	1918.0	135.60	38.02	3.334	0.36	1.00	1.30	120.0	80000.0	3000.0	35.0	-1.0	20.0	3.50	000003
508.0	24.20	2264.0	118.80	117.65	2.965	0.20	1.15	0.70	80.0	40000.0	3000.0	35.0	-1.0	20.0	3.50	000003
509.0	209.80	3300.0	127.80	80.35	2.461	0.20	1.15	0.70	120.0	80000.0	3000.0	35.0	-1.0	20.0	3.50	000003
510.0	58.84	1462.0	119.10	34.96	4.015	0.20	1.15	1.30	80.0	80000.0	3000.0	35.0	-1.0	20.0	3.50	000003
511.0	-31.33	1888.0	152.60	36.29	3.123	0.20	1.15	1.30	120.0	40000.0	3000.0	35.0	-1.0	20.0	3.50	000003
512.0	23.65	2325.0	116.90	146.05	3.058	1.80	1.00	0.70	80.0	40000.0	3000.0	35.0	-1.0	20.0	3.50	000003
513.0	169.00	3417.0	125.20	90.58	2.554	1.80	1.00	0.70	120.0	80000.0	3000.0	35.0	-1.0	20.0	3.50	000003
514.0	80.66	1487.0	115.50	38.12	4.163	1.80	1.00	1.30	80.0	80000.0	3000.0	35.0	-1.0	20.0	3.50	000003
515.0	2.47	1936.0	149.10	39.49	3.243	1.80	1.00	1.30	120.0	40000.0	3000.0	35.0	-1.0	20.0	3.50	000003
516.0	134.70	2318.0	108.90	78.62	3.131	1.80	1.15	0.70	80.0	80000.0	3000.0	35.0	-1.0	20.0	3.50	000003
517.0	59.40	3390.0	140.30	82.73	2.338	1.80	1.15	0.70	120.0	40000.0	3000.0	35.0	-1.0	20.0	3.50	000003
518.0	-20.58	1484.0	127.20	35.15	3.838	1.80	1.15	1.30	80.0	40000.0	3000.0	35.0	-1.0	20.0	3.50	000003
519.0	121.50	1925.0	138.90	30.83	3.264	1.80	1.15	1.30	120.0	80000.0	3000.0	35.0	-1.0	20.0	3.50	000003
520.0	117.20	2598.0	146.20	45.50	2.845	1.00	1.07	1.00	100.0	60000.0	2700.0	50.0	0.0	20.0	2.50	000003
521.0	126.70	4669.0	165.60	90.94	2.751	0.20	1.00	0.70	80.0	80000.0	2400.0	65.0	1.0	30.0	3.50	000003
523.0	41.35	7496.0	205.80	111.38	2.000	0.20	1.00	0.70	120.0	40000.0	2400.0	65.0	1.0	30.0	3.50	000003
522.0	-65.30	2452.0	187.30	42.19	3.169	0.20	1.00	1.30	80.0	40000.0	2400.0	65.0	1.0	30.0	3.50	000003
524.0	99.60	3616.0	205.40	36.83	2.592	0.20	1.00	1.30	120.0	80000.0	2400.0	65.0	1.0	30.0	3.50	000003
525.0	-1.83	4583.0	178.70	93.96	2.593	0.20	1.15	0.70	80.0	40000.0	2400.0	65.0	1.0	30.0	3.50	000003
527.0	212.10	7288.0	194.20	74.09	2.060	0.20	1.15	0.70	120.0	80000.0	2400.0	65.0	1.0	30.0	3.50	000003
526.0	1.83	2416.0	183.00	33.43	3.231	0.20	1.15	1.30	80.0	80000.0	2400.0	65.0	1.0	30.0	3.50	000003
528.0	-88.50	3530.0	228.10	35.58	2.438	0.20	1.15	1.30	120.0	40000.0	2400.0	65.0	1.0	30.0	3.50	000003
529.0	11.54	4774.0	175.80	104.51	2.670	1.80	1.00	0.70	80.0	40000.0	2400.0	65.0	1.0	30.0	3.50	000003
530.0	151.00	7659.0	190.30	80.35	2.120	1.80	1.00	0.70	120.0	80000.0	2400.0	65.0	1.0	30.0	3.50	000003
531.0	36.90	2495.0	177.70	35.07	3.342	1.80	1.00	1.30	80.0	80000.0	2400.0	65.0	1.0	30.0	3.50	000003
532.0	-27.90	3683.0	222.10	37.26	2.538	1.80	1.00	1.30	120.0	40000.0	2400.0	65.0	1.0	30.0	3.50	000003
533.0	96.66	4739.0	169.40	67.32	2.730	1.60	1.15	0.70	80.0	80000.0	2400.0	65.0	1.0	30.0	3.50	000003
534.0	24.40	7525.0	210.70	74.99	1.983	1.60	1.15	0.70	120.0	40000.0	2400.0	65.0	1.0	30.0	3.50	000003
535.0	-85.30	2481.0	194.00	32.63	3.136	1.60	1.15	1.30	80.0	40000.0	2400.0	65.0	1.0	30.0	3.50	000003
536.0	42.96	3628.0	214.10	29.64	2.560	1.60	1.15	1.30	120.0	80000.0	2400.0	65.0	1.0	30.0	3.50	000003
537.0	103.10	2300.0	108.00	123.73	3.145	0.20	1.00	0.70	80.0	80000.0	2400.0	35.0	-1.0	30.0	3.50	000003
538.0	30.42	3381.0	139.00	145.91	2.352	0.20	1.00	0.70	120.0	40000.0	2400.0	35.0	-1.0	30.0	3.50	000003
539.0	-9.16	1477.0	125.40	45.76	3.885	0.20	1.00	1.30	80.0	40000.0	2400.0	35.0	-1.0	30.0	3.50	000003
540.0	145.00	1922.0	136.50	38.05	3.313	0.20	1.00	1.30	120.0	80000.0	2400.0	35.0	-1.0	30.0	3.50	000003
541.0	27.72	2281.0	119.40	109.55	2.964	0.20	1.15	0.70	80.0	40000.0	2400.0	35.0	-1.0	30.0	3.50	000003
542.0	219.80	3328.0	128.70	76.97	2.461	0.20	1.15	0.70	120.0	80000.0	2400.0	35.0	-1.0	30.0	3.50	000003
543.0	68.65	1468.0	120.30	34.06	4.004	0.20	1.15	1.30	80.0	80000.0	2400.0	35.0	-1.0	30.0	3.50	000003
544.0	-35.80	1899.0	154.40	35.37	3.115	0.20	1.15	1.30	120.0	40000.0	2400.0	35.0	-1.0	30.0	3.50	000003
545.0	25.49	2345.0	117.50	131.08	3.052	1.80	1.00	0.70	80.0	40000.0	2400.0	35.0	-1.0	30.0	3.50	000003
546.0	159.80	3451.0	126.00	86.26	2.547	1.80	1.00	0.70	120.0	80000.0	2400.0	35.0	-1.0	30.0	3.50	000003
547.0	74.73	1495.0	116.60	36.86	4.145	1.80	1.00	1.30	80.0	80000.0	2400.0	35.0	-1.0	30.0	3.50	000003
548.0	3.44	1950.0	150.40	38.09	3.228	1.80	1.00	1.30	120.0	40000.0	2400.0	35.0	-1.0	30.0	3.50	000003
549.0	109.50	2358.0	111.20	78.23	3.063	1.60	1.15	0.70	80.0	80000.0	2400.0	35.0	-1.0	30.0	3.50	000003
549.0	41.11	3455.0	143.20	82.01	2.272	1.60	1.15	0.70	120.0	40000.0	2400.0	35.0	-1.0	30.0	3.50	000003
550.0	-38.45	1500.0	131.00	34.28	3.741	1.60	1.15	1.30	80.0	40000.0	2400.0	35.0	-1.0	30.0	3.50	000003
552.0	81.74	1952.0	143.90	30.39	3.176	1.60	1.15	1.30	120.0	80000.0	2400.0	35.0	-1.0	30.0	3.50	000003
553.0	107.30	2290.0	107.60	123.80	3.146	0.48	1.00	0.70	80.0	80000.0	3000.0	35.0	1.0	30.0	3.50	000003
554.0	41.35	3360.0	138.70	139.97	2.352	0.48	1.00	0.70	120.0	40000.0	3000.0	35.0	1.0	30.0	3.50	000003

N	RANGE DASH(NM)	TO DIST (FT)	VEL (FT/SEC)	TIME (SEC)	G-LOAD	BPR	TR	T/W	W/S	GW (LBS)	T4 (DEGREES)	SWEEP (DEGREES)	AB	OPR	AR	ID
555.0	-10.64	1472.0	124.90	46.73	3.877	0.48	1.00	1.30	80.0	40000.0	3000.0	35.0	1.0	30.0	3.50	000003
556.0	127.30	1913.0	135.90	38.99	3.301	0.48	1.00	1.30	120.0	80000.0	3000.0	35.0	1.0	30.0	3.50	000003
557.0	25.55	2264.0	119.00	122.54	2.950	0.20	1.15	0.70	80.0	40000.0	3000.0	35.0	1.0	30.0	3.50	000003
558.0	221.10	3300.0	128.10	82.84	2.446	0.20	1.15	0.70	120.0	80000.0	3000.0	35.0	1.0	30.0	3.50	000003
559.0	58.24	1462.0	119.50	36.32	3.973	0.20	1.15	1.30	80.0	80000.0	3000.0	35.0	1.0	30.0	3.50	000003
560.0	-36.39	1888.0	153.40	37.76	3.089	0.20	1.15	1.30	120.0	40000.0	3000.0	35.0	1.0	30.0	3.50	000003
561.0	16.38	2319.0	117.10	177.59	3.031	1.80	1.00	0.70	80.0	40000.0	3000.0	35.0	1.0	30.0	3.50	000003
562.0	139.60	3409.0	125.60	102.24	2.522	1.80	1.00	0.70	120.0	80000.0	3000.0	35.0	1.0	30.0	3.50	000003
563.0	67.35	1484.0	116.00	40.07	4.135	1.80	1.00	1.30	80.0	80000.0	3000.0	35.0	1.0	30.0	3.50	000003
564.0	0.74	1933.0	149.60	41.47	3.221	1.80	1.00	1.30	120.0	40000.0	3000.0	35.0	1.0	30.0	3.50	000003
565.0	119.20	2312.0	109.00	84.53	3.118	1.80	1.15	0.70	80.0	80000.0	3000.0	35.0	1.0	30.0	3.50	000003
566.0	52.71	3378.0	140.40	88.96	2.324	1.80	1.15	0.70	120.0	40000.0	3000.0	35.0	1.0	30.0	3.50	000003
567.0	-17.17	1481.0	127.30	36.00	3.840	1.80	1.15	1.30	80.0	40000.0	3000.0	35.0	1.0	30.0	3.50	000003
568.0	112.90	1920.0	139.10	31.57	3.263	1.80	1.15	1.30	120.0	80000.0	3000.0	35.0	1.0	30.0	3.50	000003
569.0	128.90	4680.0	163.20	92.02	2.773	0.48	1.00	0.70	80.0	80000.0	3000.0	65.0	-1.0	30.0	3.50	000003
571.0	41.95	7520.0	202.80	116.32	2.017	0.48	1.00	0.70	120.0	40000.0	3000.0	65.0	-1.0	30.0	3.50	000003
570.0	-35.98	2456.0	183.20	41.65	3.211	0.48	1.00	1.30	80.0	40000.0	3000.0	65.0	-1.0	30.0	3.50	000003
572.0	128.60	3626.0	199.80	36.18	2.634	0.48	1.00	1.30	120.0	80000.0	3000.0	65.0	-1.0	30.0	3.50	000003
573.0	8.35	4545.0	176.30	92.02	2.622	0.20	1.15	0.70	80.0	40000.0	3000.0	65.0	-1.0	30.0	3.50	000003
575.0	26.80	2401.0	178.60	32.89	3.275	0.20	1.15	1.30	80.0	80000.0	3000.0	65.0	-1.0	30.0	3.50	000003
574.0	221.00	7222.0	191.00	71.86	2.085	0.20	1.15	0.70	120.0	80000.0	3000.0	65.0	-1.0	30.0	3.50	000003
576.0	-56.23	3503.0	222.70	34.91	2.477	0.20	1.15	1.30	120.0	40000.0	3000.0	65.0	-1.0	30.0	3.50	000003
577.0	20.25	4732.0	173.80	108.36	2.692	1.80	1.00	0.70	80.0	40000.0	3000.0	65.0	-1.0	30.0	3.50	000003
578.0	195.30	7590.0	187.50	80.46	2.142	1.80	1.00	0.70	120.0	80000.0	3000.0	65.0	-1.0	30.0	3.50	000003
579.0	65.35	2478.0	174.10	35.92	3.371	1.80	1.00	1.30	80.0	80000.0	3000.0	65.0	-1.0	30.0	3.50	000003
580.0	-12.33	3654.0	217.40	38.30	2.562	1.80	1.00	1.30	120.0	40000.0	3000.0	65.0	-1.0	30.0	3.50	000003
581.0	137.30	4677.0	165.90	66.96	2.746	1.80	1.15	0.70	80.0	80000.0	3000.0	65.0	-1.0	30.0	3.50	000003
582.0	52.08	7431.0	206.50	74.59	1.996	1.80	1.15	0.70	120.0	40000.0	3000.0	65.0	-1.0	30.0	3.50	000003
583.0	-64.20	2455.0	188.30	33.07	3.156	1.80	1.15	1.30	80.0	40000.0	3000.0	65.0	-1.0	30.0	3.50	000003
584.0	96.45	3589.0	206.60	29.85	2.576	1.80	1.15	1.30	120.0	80000.0	3000.0	65.0	-1.0	30.0	3.50	000003
585.0	123.30	2596.0	147.30	45.43	3.063	1.00	1.07	1.00	100.0	60000.0	2700.0	50.0	0.0	25.0	3.50	000003
586.0	107.70	2611.0	147.60	44.89	2.838	1.00	1.07	1.00	100.0	60000.0	2400.0	50.0	0.0	25.0	2.50	000003
587.0	110.40	2571.0	146.80	48.10	2.832	0.20	1.07	1.00	100.0	60000.0	2700.0	50.0	0.0	25.0	2.50	000003
588.0	118.70	2648.0	144.60	53.68	2.897	1.00	1.00	1.00	100.0	60000.0	2700.0	50.0	0.0	25.0	2.50	000003
589.0	139.00	3728.0	140.10	78.12	2.491	1.00	1.07	0.70	100.0	60000.0	2700.0	50.0	0.0	25.0	2.50	000003
590.0	86.94	2593.0	147.00	48.06	2.817	1.00	1.07	1.00	100.0	60000.0	2700.0	50.0	1.0	25.0	2.50	000003
591.0	115.60	2030.0	124.50	47.95	2.845	1.00	1.07	1.00	100.0	60000.0	2700.0	35.0	0.0	25.0	2.50	000003
592.0	91.55	2145.0	133.70	47.02	3.263	1.00	1.07	1.00	80.0	60000.0	2700.0	50.0	0.0	25.0	2.50	000003
593.0	29.43	2596.0	154.30	49.43	2.760	1.00	1.07	1.00	100.0	40000.0	2700.0	50.0	0.0	25.0	2.50	000003
594.0	123.40	2596.0	145.70	45.65	2.845	1.00	1.07	1.00	100.0	60000.0	2700.0	50.0	0.0	25.0	2.50	000003
595.0	178.50	2596.0	141.50	44.14	2.887	1.00	1.07	1.00	100.0	80000.0	2700.0	50.0	0.0	25.0	2.50	000003
596.0	145.50	3079.0	157.10	45.00	2.542	1.00	1.07	1.00	120.0	60000.0	2700.0	50.0	0.0	25.0	2.50	000003
597.0	119.00	3896.0	184.40	44.71	2.517	1.00	1.07	1.00	100.0	60000.0	2700.0	65.0	0.0	25.0	2.50	000003
598.0	120.60	2600.0	145.60	45.40	2.847	1.00	1.07	1.00	100.0	60000.0	2700.0	50.0	-1.0	25.0	2.50	000003
599.0	84.71	2064.0	151.00	33.03	3.119	1.00	1.07	1.30	100.0	60000.0	2700.0	50.0	0.0	25.0	2.50	000003
600.0	105.20	2612.0	148.50	45.72	2.825	1.00	1.15	1.00	100.0	60000.0	2700.0	50.0	0.0	25.0	2.50	000003
601.0	102.10	2623.0	146.00	44.71	2.834	1.80	1.07	1.00	100.0	60000.0	2700.0	50.0	0.0	25.0	2.50	000003
602.0	126.60	2591.0	145.10	46.08	2.847	1.00	1.07	1.00	100.0	60000.0	3000.0	50.0	0.0	25.0	2.50	000003
603.0	125.00	2597.0	145.70	45.61	2.845	1.00	1.07	1.00	100.0	60000.0	2700.0	50.0	0.0	30.0	2.50	000003

APPENDIX B
SAMPLE REGRESSION RESULTS

The following computerized listing is a sample output of the regression routine used in the RSTEP TASK IV Study. The example presented in a forced second order polynomial regression of the log of TOGW for a half replication CCD pattern as a function seven variables. The major subsections of the printout are described below:

General Processor	—	Data used in the regression.
Check Points (1st Set)	—	Data points excluded from the regression because they are not required in the replication.
Check Points (2nd Set)	—	Data points excluded from the regression because they are not included in the data required for the number of variables considered.
Regression Equation Coefficients	—	Listing of dependent variable and corresponding regression equation.
Quadratic Solution	—	Quadratic solution for the independent variable dash range for each of the sets of data points noted above. Note that some of the large percent errors in dash radius are due to near zero values of dash radius.

RSTEP UTILITY PROGRAM
TRIAL= 1.

GENERAL PROCESSOR (TRANSFORMATIONS+CHECK PTS)

	YOBS	YCALC	DEL	PERCENT		PT NO
1	79999.875	81556.375	1556.500	1.95		10.
2	39999.930	41436.402	1436.473	3.59		13.
3	79999.875	76141.812	-3858.062	-4.82		15.
4	39999.930	40382.801	382.871	0.96		16.
5	79999.875	78544.125	-1455.750	-1.82		20.
6	39999.930	40882.168	882.238	2.21		21.
7	79999.875	78021.250	-1978.625	-2.47		23.
8	39999.930	41385.102	1385.172	3.46		26.
9	39999.930	39725.074	-274.855	-0.69		28.
10	79999.875	78718.375	-1281.500	-1.60		29.
11	39999.930	40497.418	497.488	1.24		31.
12	79999.875	80017.812	17.938	0.02		34.
13	39999.930	40881.348	881.418	2.20		36.
14	79999.875	82835.187	2835.312	3.54		39.
15	39999.930	39297.328	-702.602	-1.76		41.
16	79999.875	75475.250	-4524.625	-5.66		42.
17	59999.895	62003.816	2003.922	3.34		49.
18	39999.930	39771.172	-228.758	-0.57		55.
19	79999.875	83259.375	3259.500	4.07		58.
20	79999.875	81371.000	1371.125	1.71		60.
21	39999.930	38976.605	-1023.324	-2.56		61.
22	79999.875	81489.187	1489.312	1.86		64.
23	39999.930	40688.191	688.262	1.72		65.
24	39999.930	40134.012	134.082	0.34		67.
25	79999.875	76940.125	-3059.750	-3.82		70.
26	79999.875	76285.062	-3714.812	-4.64		73.
27	39999.930	40294.816	294.887	0.74		74.
28	39999.930	40535.172	535.242	1.34		76.
29	79999.875	80162.187	162.312	0.20		79.
30	39999.930	40283.754	283.824	0.71		80.
31	79999.875	77919.000	-2080.875	-2.60		83.
32	79999.875	82121.875	2122.000	2.65		85.
33	39999.930	38576.078	-1423.852	-3.56		86.
34	59999.895	57690.109	-2309.785	-3.85		88.
35	59999.895	60585.984	586.090	0.98		89.
36	59999.895	59526.102	-473.793	-0.79		90.
37	59999.895	58308.332	-1691.562	-2.82		91.
38	59999.895	59876.824	-123.070	-0.21		92.
39	39999.930	36630.324	-3369.605	-8.42	MAX	93.
40	59999.895	60324.582	324.687	0.54		94.
41	79999.875	76950.250	-3049.625	-3.81		95.
42	59999.895	62133.391	2133.496	3.56		96.
43	59999.895	63601.504	3601.609	6.00		97.
44	59999.895	62499.355	2499.461	4.17		98.
45	59999.895	62732.004	2732.109	4.55		99.
46	59999.895	60367.687	367.793	0.61		100.

47	39999.930	40450.328	450.398		1.13	101.
48	79999.875	80253.562	253.687		0.32	104.
49	79999.875	78743.062	-1256.812		-1.57	106.
50	39999.930	39293.879	-706.051		-1.77	107.
51	79999.875	84238.062	4238.187		5.30	110.
52	39999.930	40219.875	219.945		0.55	111.
53	39999.930	39880.289	-119.641		-0.30	113.
54	79999.875	80735.312	735.437		0.92	116.
55	79999.875	79982.125	-17.750		-0.02	118.
56	39999.930	40297.930	298.000		0.75	119.
57	39999.930	41984.941	1985.012		4.96	121.
58	79999.875	78801.000	-1198.875		-1.50	124.
59	39999.930	38557.945	-1441.984		-3.60	125.
60	79999.875	79255.687	-744.187		-0.93	128.
61	79999.875	79690.437	-309.437		-0.39	130.
62	39999.930	39101.922	-898.008		-2.25	131.
63	59999.895	60324.582	324.687		0.54	133.
64	79999.875	83903.750	3903.875		4.88	135.
65	39999.930	39358.387	-641.543		-1.60	136.
66	39999.930	40659.410	659.480		1.65	138.
67	79999.875	78822.812	-1177.062		-1.47	141.
68	39999.930	39135.684	-864.246		-2.16	142.
69	79999.875	75425.562	-4574.312		-5.72	145.
70	79999.875	75263.062	-4736.812	MAX	-5.92	147.
71	39999.930	43216.879	3216.949		8.04	148.
72	39999.930	40324.305	324.375		0.81	150.
73	79999.875	79439.375	-560.500		-0.70	153.
74	79999.875	77813.437	-2186.437		-2.73	155.
75	39999.930	39430.633	-569.297		-1.42	156.
76	79999.875	81557.750	1557.875		1.95	159.
77	39999.930	40749.082	749.152		1.87	160.
78	39999.930	39106.398	-893.531		-2.23	162.
79	79999.875	83793.437	3793.562		4.74	165.

AVG DEL	SEE	AVG PERCENT	PEE	R2
1477.17	2647.45	2.40	4.11	0.9908

CHECK POINTS

	YOBS	YCALC	DEL		PERCENT		PT NO
1	39999.930	42131.141	2131.211		5.33		11.
2	79999.875	76765.625	-3234.250		-4.04		12.
3	39999.930	42260.395	2260.465		5.65		14.
4	79999.875	77769.750	-2230.125		-2.79		17.
5	39999.930	40181.996	182.066		0.46		19.
6	79999.875	72515.000	-7484.875	MAX	-9.36	MAX	22.
7	39999.930	39404.469	-595.461		-1.49		24.
8	79999.875	79027.312	-972.562		-1.22		25.
9	79999.875	81198.437	1198.562		1.50		27.
10	39999.930	39498.305	-501.625		-1.25		30.
11	79999.875	78840.500	-1159.375		-1.45		32.
12	39999.930	41421.668	1421.738		3.55		33.
13	79999.875	82285.125	2285.250		2.86		37.
14	39999.930	38100.918	-1899.012		-4.75		38.
15	79999.875	83064.062	3064.187		3.83		40.
16	39999.930	40579.148	579.219		1.45		43.
17	79999.875	75740.062	-4259.812		-5.32		56.
18	39999.930	37277.953	-2721.977		-6.80		57.
19	39999.930	40934.172	934.242		2.34		59.
20	79999.875	80599.562	599.687		0.75		62.
21	39999.930	40220.375	220.445		0.55		63.
22	79999.875	85626.562	5626.687		7.03		66.
23	79999.875	75046.375	-4953.500		-6.19		68.
24	39999.930	39896.609	-103.320		-0.26		69.
25	39999.930	39289.383	-710.547		-1.78		72.
26	79999.875	81275.312	1275.437		1.59		75.
27	79999.875	74692.562	-5307.312		-6.63		77.
28	39999.930	38418.137	-1581.793		-3.95		78.
29	79999.875	78859.750	-1140.125		-1.43		81.
30	39999.930	41652.133	1652.203		4.13		82.
31	39999.930	40794.809	794.879		1.99		84.
32	79999.875	84675.000	4675.125		5.84		87.
33	79999.875	81672.500	1672.625		2.09		102.
34	39999.930	39537.875	-462.055		-1.16		103.
35	39999.930	38650.168	-1349.762		-3.37		105.
36	79999.875	79851.437	-148.437		-0.19		108.
37	39999.930	39274.398	-725.531		-1.81		109.
38	79999.875	78664.125	-1335.750		-1.67		112.
39	79999.875	76959.437	-3040.437		-3.80		114.
40	39999.930	42384.910	2384.980		5.96		115.
41	39999.930	41053.020	1053.090		2.63		117.
42	79999.875	79154.625	-845.250		-1.06		120.
43	79999.875	77892.812	-2107.062		-2.63		122.
44	39999.930	41199.035	1199.105		3.00		123.
45	79999.875	75128.625	-4871.250		-6.09		126.
46	39999.930	39614.191	-385.738		-0.96		127.
47	39999.930	39231.387	-768.543		-1.92		129.
48	79999.875	84464.750	4464.875		5.58		132.
49	39999.930	40387.922	387.992		0.97		134.
50	79999.875	81554.562	1554.687		1.94		137.

51	79999.875	79310.187	-689.687	-0.86	139.
52	39999.930	40473.789	473.859	1.18	140.
53	79999.875	79611.750	-388.125	-0.49	143.
54	39999.930	39709.129	-290.801	-0.73	144.
55	39999.930	41390.195	1390.266	3.48	146.
56	79999.875	78168.812	-1831.062	-2.29	149.
57	79999.875	80979.437	979.562	1.22	151.
58	39999.930	39457.492	-542.437	-1.36	152.
59	39999.930	40455.574	455.645	1.14	154.
60	79999.875	82786.562	2786.687	3.48	157.
61	39999.930	38763.457	-1236.473	-3.09	158.
62	79999.875	81004.125	1004.250	1.26	161.
63	79999.875	81966.062	1966.187	2.46	163.
64	39999.930	40328.918	328.988	0.82	164.

CUMMULATIVE

AVG DEL	SEE	AVG PERCENT	PEE	R2
1591.42	2461.90	2.57	3.73	0.9908

CHECK POINTS

	YOBS	YCALC	DEL	PERCENT		PT NO
1	59999.895	59640.715	-359.180	-0.60		1.
2	39999.930	37065.785	-2934.145	-7.34		2.
3	59999.895	58883.738	-1116.156	-1.86		3.
4	79999.875	75517.062	-4482.812	-5.60		4.
5	59999.895	60030.172	30.277	0.05		5.
6	59999.895	57479.723	-2520.172	-4.20		6.
7	59999.895	59125.930	-873.965	-1.46		7.
8	59999.895	59992.113	-7.781	-0.01		8.
9	59999.895	62195.934	2196.039	3.66		9.
10	59999.895	60541.340	541.445	0.90		18.
11	59999.895	64519.285	4519.391	7.53		35.
12	59999.895	63925.984	3926.090	6.54		44.
13	59999.895	61636.754	1636.859	2.73		45.
14	59999.895	60486.859	486.965	0.81		46.
15	59999.895	61100.371	1100.477	1.83		47.
16	39999.930	37898.484	-2101.445	-5.25		48.
17	79999.875	79258.250	-741.625	-0.93		50.
18	59999.895	64864.031	4864.137	8.11		51.
19	59999.895	65372.207	5372.312 MAX	8.95	MAX	52.
20	59999.895	64240.723	4240.828	7.07		53.
21	59999.895	64738.086	4738.191	7.90		54.
22	59999.895	61761.910	1762.016	2.94		71.

CUMMULATIVE

AVG DEL	SEE	AVG PERCENT	PEE	R2
1685.60	2539.34	2.75	3.96	0.9908

REGRESSION EQUATION COEFFICIENTS

DEP VAR CONSTANT EXPONENT A0

LOG (GW + 0.0)= 0.81203D+01 +

TERM	ELEMENT	VARIABLE	EXPONENT	COEFFICIENT
1	1	BPR	0.100E+01	-0.22595D+00
2	1	BPR	0.200E+01	0.55481D-01
3	1	W/S	0.100E+01	-0.11228D-01
4	1	W/S	0.200E+01	0.48654D-04
5	1	TR	0.100E+01	-0.67622D+01
6	1	TR	0.200E+01	0.29641D+01
7	1	RNGE	0.100E+01	0.76748D-02
8	1	RNGE	0.200E+01	-0.29047D-05
9	1	T/W	0.100E+01	-0.95640D+00
10	1	T/W	0.200E+01	0.24326D+00
11	1	T4	0.100E+01	0.23291D-03
12	1	T4	0.200E+01	-0.39388D-08
13	1	SWP	0.100E+01	-0.15266D-01
14	1	SWP	0.200E+01	0.13671D-03
15	1	BPR	0.100E+01	0.61019D-04
	2	W/S	0.100E+01	
16	1	BPR	0.100E+01	0.12827D+00
	2	TR	0.100E+01	
17	1	BPR	0.100E+01	0.12653D-03
	2	RNGE	0.100E+01	
18	1	BPR	0.100E+01	0.86429D-03
	2	T/W	0.100E+01	
19	1	BPR	0.100E+01	-0.30391D-04
	2	T4	0.100E+01	
20	1	BPR	0.100E+01	0.81653D-04
	2	SWP	0.100E+01	
21	1	W/S	0.100E+01	0.27563D-02
	2	TR	0.100E+01	
22	1	W/S	0.100E+01	-0.10193D-04
	2	RNGE	0.100E+01	
23	1	W/S	0.100E+01	0.62042D-03
	2	T/W	0.100E+01	
24	1	W/S	0.100E+01	-0.12497D-06
	2	T4	0.100E+01	
25	1	W/S	0.100E+01	-0.83372D-05
	2	SWP	0.100E+01	
26	1	TR	0.100E+01	-0.16979D-02
	2	RNGE	0.100E+01	
27	1	TR	0.100E+01	0.77895D+00
	2	T/W	0.100E+01	
28	1	TR	0.100E+01	-0.14107D-03
	2	T4	0.100E+01	
29	1	TR	0.100E+01	0.26383D-02
	2	SWP	0.100E+01	
30	1	RNGE	0.100E+01	-0.54448D-03
	2	T/W	0.100E+01	
31	1	RNGE	0.100E+01	0.22327D-07
	2	T4	0.100E+01	

32	1	RNGE	0.100E+01	-0.12931D-04
	2	SWP	0.100E+01	
33	1	T/W	0.100E+01	-0.44285D-04
	2	T4	0.100E+01	
34	1	T/W	0.100E+01	0.24062D-02
	2	SWP	0.100E+01	
35	1	T4	0.100E+01	0.20374D-06
	2	SWP	0.100E+01	

CALCULATE TOGW FROM RANGE REGRESS OR VICE VERSA

CALCULATE SELECTED VARIABLE (TOGW,RANGE,OTHER VARIABLE) USING QUADRATIC SOLUTION

	YOBS	YCALC	DEL	PERCENT	PT NO
1	148.900	145.074	-3.826	-2.57	10.
2	17.970	13.407	-4.563	-25.39	13.
3	63.950	71.828	7.878	12.32	15.
4	-24.970	-26.414	-1.444	5.78	16.
5	117.700	120.895	3.195	2.71	20.
6	25.260	21.685	-3.575	-14.15	21.
7	55.090	60.216	5.126	9.31	23.
8	-49.960	-54.622	-4.662	9.33	26.
9	-70.190	-69.063	1.127	-1.61	28.
10	47.020	49.968	2.948	6.27	29.
11	12.530	10.696	-1.834	-14.64	31.
12	198.100	198.042	-0.058	-0.03	34.
13	-40.580	-43.571	-2.991	7.37	36.
14	91.610	84.050	-7.560	-8.25	39.
15	11.910	14.700	2.790	23.43	41.
16	94.180	103.651	9.471	10.06	42.
17	93.870	87.773	-6.097	-6.49	49.
18	-2.207	-1.436	0.771	-34.94	55.
19	148.000	139.485	-8.515	-5.75	58.
20	69.390	66.507	-2.883	-4.15	60.
21	-39.160	-35.081	4.079	-10.42	61.
22	126.000	122.492	-3.508	-2.78	64.
23	21.370	18.384	-2.986	-13.97	65.
24	-58.380	-58.860	-0.480	0.82	67.
25	59.660	68.593	8.933	14.97	70.
26	106.000	113.316	7.316	6.90	73.
27	31.430	30.322	-1.108	-3.52	74.
28	-19.450	-21.223	-1.773	9.11	76.
29	105.500	105.087	-0.413	-0.39	79.
30	21.100	20.107	-0.993	-4.70	80.
31	159.500	165.679	6.179	3.87	83.
32	68.640	64.084	-4.556	-6.64	85.
33	-53.140	-47.442	5.698	-10.72	86.
34	95.000	103.160	8.160	8.59	88.
35	84.840	82.818	-2.021	-2.38	89.
36	96.170	97.718	1.548	1.61	90.
37	124.700	130.634	5.934	4.76	91.
38	80.920	81.294	0.374	0.46	92.
39	12.510	27.462	14.952	119.52	93.
40	105.500	104.368	-1.132	-1.07	94.
41	161.200	171.090	9.890	6.14	95.
42	121.000	112.529	-8.471	-7.00	96.
43	67.060	55.310	-11.750	-17.52	97.
44	103.800	94.760	-9.040	-8.71	98.
45	100.700	91.970	-8.730	-8.67	99.
46	107.200	105.915	-1.285	-1.20	100.
47	3.351	1.643	-1.708	-50.98	101.

48	185.300	184.305	-0.995		-0.54		104.
49	49.790	52.875	3.085		6.20		106.
50	-65.310	-62.205	3.105		-4.75		107.
51	161.100	147.950	-13.149		-8.16		110.
52	25.080	23.923	-1.157		-4.61		111.
53	-90.990	-90.523	0.467		-0.51		113.
54	52.970	50.438	-2.532		-4.78		116.
55	127.700	127.745	0.045		0.04		118.
56	34.770	33.459	-1.311		-3.77		119.
57	-41.190	-48.217	-7.027		17.06		121.
58	89.140	92.795	3.655		4.10		124.
59	4.056	9.827	5.771		142.29		125.
60	190.200	193.368	3.168		1.67		128.
61	31.700	32.438	0.738		2.33		130.
62	-94.630	-90.848	3.782		-4.00		131.
63	105.500	104.368	-1.132		-1.07		133.
64	127.600	118.100	-9.500		-7.44		135.
65	17.450	20.411	2.961		16.97		136.
66	-57.560	-60.002	-2.442		4.24		138.
67	86.600	90.524	3.925		4.53		141.
68	-0.438	3.203	3.641		-831.07	MAX	142.
69	192.400	217.552	25.152	MAX	13.07		145.
70	21.860	34.334	12.474		57.06		147.
71	-81.970	-95.977	-14.007		17.09		148.
72	16.640	15.465	-1.175		-7.06		150.
73	183.300	185.218	1.918		1.05		153.
74	66.970	72.112	5.142		7.68		155.
75	-38.040	-35.598	2.442		-6.42		156.
76	148.200	143.950	-4.250		-2.87		159.
77	35.560	31.922	-3.638		-10.23		160.
78	-74.060	-70.688	3.372		-4.55		162.
79	78.210	66.125	-12.085		-15.45		165.

AVG DEL	SEE	AVG PERCENT	PEE	R2
4.73	8.64	22.08	131.01	0.0

CALCULATE TOGW FROM RANGE REGRESS OR VICE VERSA

CHECK POINTS

	YOBS	YCALC	DEL	PERCENT		PT NO
1	34.470	26.596	-7.874	-22.84		11.
2	104.600	110.956	6.356	6.08		12.
3	-21.370	-28.677	-7.307	34.19		14.
4	87.470	93.085	5.615	6.42		17.
5	14.100	13.469	-0.631	-4.47		19.
6	132.200	154.045	21.845	16.52		22.
7	-64.300	-61.992	2.308	-3.59		24.
8	47.860	49.922	2.062	4.31		25.
9	66.870	63.432	-3.438	-5.14		27.
10	-63.450	-61.637	1.813	-2.86		30.
11	124.100	126.907	2.807	2.26		32.
12	26.860	20.656	-6.204	-23.10		33.
13	66.260	61.460	-4.799	-7.24		37.
14	-49.610	-42.000	7.610	-15.34		38.
15	149.100	140.919	-8.181	-5.49		40.
16	-0.096	-2.047	-1.951	2035.05	MAX	43.
17	93.290	102.057	8.767	9.40		56.
18	4.312	15.189	10.877	252.25		57.
19	-35.200	-38.365	-3.165	8.99		59.
20	92.960	91.347	-1.613	-1.73		62.
21	8.618	7.813	-0.805	-9.35		63.
22	182.700	164.118	-18.582	-10.17		66.
23	41.320	52.874	11.554	27.96		68.
24	-65.160	-64.734	0.426	-0.65		69.
25	13.450	15.759	2.309	17.16		72.
26	152.400	149.248	-3.152	-2.07		75.
27	69.360	80.409	11.049	15.93		77.
28	-22.970	-16.801	6.169	-26.86		78.
29	126.100	128.631	2.531	2.01		81.
30	37.330	30.574	-6.756	-18.10		82.
31	-40.030	-42.767	-2.737	6.84		84.
32	91.540	79.060	-12.480	-13.63		87.
33	126.400	122.194	-4.206	-3.33		102.
34	19.490	21.658	2.168	11.13		103.
35	-69.640	-64.532	5.108	-7.34		105.
36	83.490	83.988	0.498	0.60		108.
37	4.798	7.900	3.102	64.65		109.
38	222.600	230.946	8.346	3.75		112.
39	24.690	32.674	7.984	32.34		114.
40	-88.930	-99.344	-10.414	11.71		115.
41	17.840	14.039	-3.801	-21.31		117.
42	179.200	182.083	2.884	1.61		120.
43	58.920	63.802	4.882	8.29		122.
44	-39.940	-44.926	-4.986	12.48		123.
45	123.000	136.304	13.304	10.82		126.
46	21.250	23.107	1.857	8.74		127.
47	-85.180	-82.335	2.845	-3.34		129.
48	59.310	45.947	-13.363	-22.53		132.

49	1.408	-0.042	-1.450	-102.95	134.
50	184.200	178.360	-5.840	-3.17	137.
51	55.310	56.993	1.683	3.04	139.
52	-53.830	-55.894	-2.064	3.83	140.
53	138.900	140.075	1.175	0.85	143.
54	17.920	19.432	1.512	8.44	144.
55	-83.380	-88.698	-5.318	6.38	146.
56	48.040	54.394	6.354	13.23	149.
57	131.200	128.922	-2.278	-1.74	151.
58	33.890	36.302	2.412	7.12	152.
59	-39.570	-41.218	-1.648	4.16	154.
60	114.100	105.360	-8.740	-7.66	157.
61	11.050	16.031	4.981	45.07	158.
62	212.000	207.458	-4.542	-2.14	161.
63	51.660	46.881	-4.779	-9.25	163.
64	-74.920	-76.328	-1.408	1.88	164.

AVG DEL	CUMMULATIVE SEE	AVG PERCENT	PEE	R2
4.99	7.60	33.62	215.50	0.0

CALCULATE TOGW FROM RANGE REGRESS OR VICE VERSA

CHECK POINTS

	YOBS	YCALC	DEL	PERCENT		PT NO
1	85.170	86.278	1.108	1.30		1.
2	5.605	17.454	11.849	211.40	MAX	2.
3	104.300	107.691	3.391	3.25		3.
4	131.100	143.244	12.144	9.26		4.
5	44.720	44.633	-0.087	-0.19		5.
6	53.480	60.660	7.180	13.43		6.
7	65.920	68.307	2.387	3.62		7.
8	81.310	81.335	0.025	0.03		8.
9	97.430	90.040	-7.390	-7.59		9.
10	75.080	73.541	-1.539	-2.05		18.
11	82.890	69.279	-13.611	-16.42		35.
12	79.510	67.738	-11.772	-14.81		44.
13	86.250	81.573	-4.677	-5.42		45.
14	108.900	107.442	-1.458	-1.34		46.
15	72.360	69.394	-2.966	-4.10		47.
16	10.470	18.900	8.430	80.52		48.
17	142.800	144.796	1.996	1.40		50.
18	108.300	92.034	-16.265	-15.02		51.
19	63.480	47.835	-15.645	-24.65		52.
20	93.100	79.793	-13.306	-14.29		53.
21	91.180	77.857	-13.323	-14.61		54.
22	94.940	89.566	-5.374	-5.66		71.

	CUMMULATIVE			
AVG DEL	SEE	AVG PERCENT	PEE	R2
5.27	7.84	31.87	197.32	0.0

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